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ASD-TDR-62-1023

STUDY OF PARACHUTE SCALE EFFECTS

TECHNICAL DOCUMENTARY REPORT ASD-TDR-62-1023

JANUARY 1963

Flight Accessories Laboratory
Aeronautical Systems Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

Project No. 6065, Task No. 606502

(Prepared under Contract No. AF 33(657)-8073
by Technology Incorporated, Dayton, Ohio;
Author: William B. Walcott.)

NOTICES

Aeronautical Systems Division, Dir/Aero-Mechanics, Flight Accessories Lab, Wright-Patterson AFB, Ohio.
Rpt No. ASD-TDR-62-1023. STUDY OF PARACHUTE SCALE EFFECTS. Final report, Dec 62, 92p., incl illus., tables, 158 refs.
Unclassified Report

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FOREWORD

This report was prepared by Technology Incorporated, Dayton, Ohio, in compliance with United States Air Force Contract Number AF 33(657)-8073, initiated by the Retardation and Recovery Branch, Flight Accessories Laboratory, Directorate of Aeromechanics, Aeronautical Systems Division. The original Air Force Project Engineer was Mr. Clint Eckstrom; in the later phases of the program, Mr. Lawrence L. Watson assumed this position.

Technology Incorporated inaugurated the program on 15 February 1962 and completed its investigation on 15 November 1962 under the supervision of Mr. William B. Walcott, Project Engineer. Other staff members contributing significantly to the project were Mr. J. Patrick Ray, who performed the statistical analysis, and Mr. Krishan Joshi, who conducted the literature survey.

ABSTRACT

A study was conducted to determine the effects of changing scale upon drag coefficient, filling time, peak opening force, and stability for single, unreefed textile parachute canopies. The investigation was confined to Flat Circular, Extended Skirt, Ringslot, Ribless Guide Surface, Circular Flat Ribbon, and Conical Ribbon parachutes operating in the subsonic flow regime at altitudes below 20,000 feet. As an integral part of the study, a survey of the existing literature and test data, a compilation of all pertinent data, and recommendations for future experimental investigations were made. Scaling equations with associated 95-percent confidence intervals were developed for the drag coefficient of the Flat Circular and Extended Skirt parachutes through the use of a multiple regression analysis which indicates the significant variables and their functional forms. Because the available data was poorly distributed, the equations will have to be used circumspectly to avoid misleading conclusions.

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LIST OF SYMBOLS

Symbol	Concept	Dimensions
b	Estimated Regression Coefficient	none
b'_i	Estimated Standard Partial Regression Coefficient	none
C	An Element of the Inverse Matrix	none
C_{D_o}	Drag Coefficient Based on S_o	none
C_{D_p}	Drag Coefficient Based on S_p	none
D_o	Nominal Diameter	feet
D_p	Projected Diameter	feet
d.f.	Degree of Freedom	none
d_o	Estimated Constant of the Regression Model	none
F	Random Variable with Snedecor's F Distribution	none
F_o	Opening Shock Force	pounds
F_r	Froude Number, $\sqrt{V^2/q D_o}$	none
L_s	Riser Length	feet
L	Suspension Line Length	feet
M	Mach Number	none
M.S.	Mean Square	none
N_g	Number of Gores	none
n	Sample Size	none
q	Dynamic Pressure	pounds/feet^2
R^2	Square of the Multiple Correlation Coefficient	none
Re	Reynolds Number	none

LIST OF SYMBOLS (cont'd)

Symbol	Concept	Dimensions
S_o	Nominal Surface Area	$feet^2$
S_p	Projected Area	$feet^2$
S_v	Vent Area	$feet^2$
S.S.	Sum of Squares	none
SSE	Error Sum of Squares	none
SSR	Regression Sum of Squares	none
SST	Total Sum of Squares	none
s^2	Estimated Variance	none
t	Random Variable with Student's "t" Distribution	none
t_f	Canopy Filling Time	seconds
V	Velocity	feet/second
W	Gross Weight	pounds
X	Independent Variable	none
Y	Actual Value of the Dependent Variable	none
$\hat{Y}$	Predicted Value of the Dependent Variable	none
α	Type I Error	none
β	Actual Regression Coefficient	none
δ	Actual Constant of the Regression Model	none
λ	Porosity at $\Delta P = 1/2$ inch of Water	$feet^3/feet^2$ - minute
μ	Mean of the Dependent Variable	none
σ^2	Variance	none

SECTION I

INTRODUCTION

Suitable scaling equations for textile parachutes would substantially reduce the testing necessary to define their operating characteristics. Instead of using current methods of testing and modifying full-scale parachutes until the desired results are obtained, scale models in conjunction with the scaling equations would suffice; then, if desired, a full-scale model could be employed to verify the results.

This study was intended primarily to determine whether sufficient data exists which could define appropriate scaling equations for the selected parachute types. Data voids and future test needs were to be noted. If sufficient information were available, the scaling equations were to be derived.

To determine the scaling equations, it was decided at the outset to use a multiple regression analysis, a statistical technique believed to be novel in its application to the parachute field. Several reasons dictated the use of a regression analysis rather than the more conventional engineering methods commonly applied to a study of this nature. Any other type of analysis could not handle the many variables involved. These variables were numerous because the data for determining the scaling equations were collected from many different tests; for example, if sufficient data were available over the desired canopy area range, other variables, such as different canopy loadings, and different chute porosities, would also be present. Furthermore, use of a regression analysis would enable determination of the significance of a given variable, the functional form of the variable, the goodness of fit of the equation, and the confidence limits for the final results.

SECTION II

PARACHUTE SCALE EFFECTS

A. Basic Concepts of Scale Effects

A parachute scale effect can be defined as any change in a parachute's operating or performance characteristics caused solely by a change in canopy size. Such a change is brought about because change in canopy size can alter certain geometric and aerodynamic properties of the parachute. These effects can be significant in some situations or virtually negligible in others, but are always present to some degree in any scale model testing. As in any scale

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model testing, if this effect cannot be assessed, the test results can prove to be useless. The main difficulty in parachute scaling is the impossibility of assessing this change theoretically.

The change in parachute performance characteristics as effected by scaling manifests itself as a change in parachute drag coefficient, stability, filling time, or peak opening force. If these variables are defined as the dependent variables, then the problem is to define their change in terms of variations of the independent variables caused by a change in parachute size (scale). The most obvious independent scaling variable is parachute canopy area; however, there are several other independent variables which reflect changes in size that may be significant. Reynolds number and Froude number are such independent variables since by their definitions they vary with a change in size. Other independent variables which can be effected by a change in size are the number of gores and the ratio of their number to the canopy diameter. It is obvious that one or both of these changes will occur with a change in parachute size.

However, a variance in gore number does not necessarily constitute a scaling variable. There are three questions which must be satisfied before a variable can be considered a scaling variable. These questions can be enumerated as follows:

1) Does the variable change with a change in scale?

2) Does the variable affect the performance of the parachute?

3) Is the only way to assess the effect of the variable to consider it simultaneously with a change in canopy size (scale)?

Due to the manner in which the number of gores in a parachute vary with a change in canopy size, the answers to all three questions must be in the affirmative, and for question 3 this is reasonable when it is considered that a 1-foot nominal diameter scale model of a 50-foot nominal diameter chute cannot possibly have the same gore arrangement as the model. The 50-foot nominal diameter chute will have approximately 50 gores while for practical reasons the 1-foot diameter model would probably be constructed with 10 to 20 gores. To ascertain the effect of the change in gore arrangement it is necessary to consider it in conjunction with the change in scale since the scale model will not be constructed with either the same number of gores or the same ratio of number of gores to nominal diameter as the full scale chute. At the same time the effect of this change in gore arrangement cannot be assessed independently since scale model chutes and large diameter chutes will probably never be constructed with the same gore arrangement due to the practicalities of construction.

Other variables which affect parachute performance but are not scaling variables since they do not satisfy question 3—since their effects can be assessed independently—are:

a) porosity
b) suspension line length/nominal diameter
c) number of vertical ribbons
d) number of horizontal ribbons
e) space between vertical tapes/gore width at base
f) open spacing/ribbon width
g) canopy loading
h) riser length/nominal diameter
i) vent area/nominal surface area
j) velocity
k) dynamic pressure

Even though these above listed variables cannot be considered as scaling variables, they still may be present in the scaling equations due to their presence in an interaction term.

A special class of independent variables, of which Reynolds number and Froude number are examples, is defined as an interaction term. If a term is differentiated with respect to the variable denoting canopy size and other variables are still present, the term is defined as an interaction term. For example,

$$Re = \frac{\rho V D_0}{\mu}$$

which upon partial differentiation with respect to D_0 becomes

$$\frac{\partial Re}{\partial D_0} = \frac{\rho V}{\mu}$$

From this rather simple example it can be seen that, if Reynolds number is significant for scaling, the variables ρ , μ , and V are also significant. Therefore, even though these variables are held constant from the full scale to the scale model tests, the value of the variable will determine the amount of change in the parachute's operating characteristics due to scaling. From the preceding discussion it can be concluded that almost any variable, for example, velocity, might possibly play an important role for scaling if it appears in a significant interaction term. An interaction term which was found to be significant for the definition of the scaling effects on filling time and opening shock was $\frac{\rho D_0}{V^{.9}}$. It is possible that interaction terms involving other variables may also be significant even though none were found.

In summary then, the aerodynamic and geometric parameters,

a) nominal surface area,
b) number of gores,
c) number of gores/nominal diameter,

d) Reynolds number, and
e) Froude number

can be assumed to be scaling variables and the other parameters, itemized previously, will enter into the scaling equations only if they are present in interaction terms.

B. Discussion of the Literature Surveyed

Literature was surveyed extensively to determine whether sufficient test data were available to permit an analysis leading to the definition of the appropriate scaling equations. The data collected during this survey is summarized and presented in Appendix II. The survey was limited to Solid Flat Circular, Extended Skirt, Ringslot, Ribless Guide Surface, Flat and Conical Ribbon parachutes operating at indicated airspeeds below 300 knots and altitudes less than 20,000 feet.

Since the data were collected from a great many different reports, there were many variables present which could affect the different performance characteristics of the parachutes and yet not be true scaling variables. Since this was the case, it was necessary to consider several more independent variables than would normally be required to arrive at the scaling equations. The independent variables whose values were considered necessary were S_o, l_s/D_o, N_g/D_o, l_r/D_o, S_v/S_o, λ, W/S_o, V, q, Re, M, and Fr. For this reason, a data point would be discarded unless a reasonable and logical assumption could be made of the value of the missing variable or variables. A more complete discussion of the literature survey is included in Appendix II with the data summary.

It was felt that sufficient data was available to determine the regression equations for drag coefficient for the Solid Flat Circular, Extended Skirt, Flat Ribbon, Ringslot, and Ribless Guide Surface parachutes. Also, there appeared to be sufficient data for filling time and peak opening force for both the Flat Circular and Extended Skirt parachutes. However, for reasons which will be explained later, the only attempts to derive scaling equations which yielded reasonable results were for the Flat Circular and Extended Skirt parachutes for drag coefficient.

Other than the data for the above mentioned parachutes, the available data were either insufficient or nonexistent. Data for any of the performance characteristics for the Conical Ribbon parachute were so meager that any attempt to summarize and present them would serve no useful purpose. Since no common description or definition of stability has been developed in the parachute realm, the available data in the literature could not be utilized. For full-scale parachutes, the period of oscillation or amount of oscillation was acquired. For scale model wind tunnel tests, however, pitching moment and the stable angle of attack were obtained. Because of this and the fact that much of the stability data appeared to have been observed rather than measured, any attempt to define the scaling equations or to present the data in a systematic form was abandoned.

C. Utilization of Regression Analysis

Because of the scatter of data caused by the many variables in the collected data, a multiple regression analysis was selected as the technique most capable of defining the desired scaling equations. Figure 1, for example, shows the wide scatter of drag coefficient values for various nominal surface areas for the Circular Flat parachute. This figure shows that there are other variables in addition to canopy size which influence the value of the drag coefficient, for, without these other variables, the scatter for any nominal surface area would be appreciably less. Therefore, it was necessary to try not only to extract the scaling effects from the data but also to eliminate the variations due to nonscaling variables, such as suspension line length and velocity.

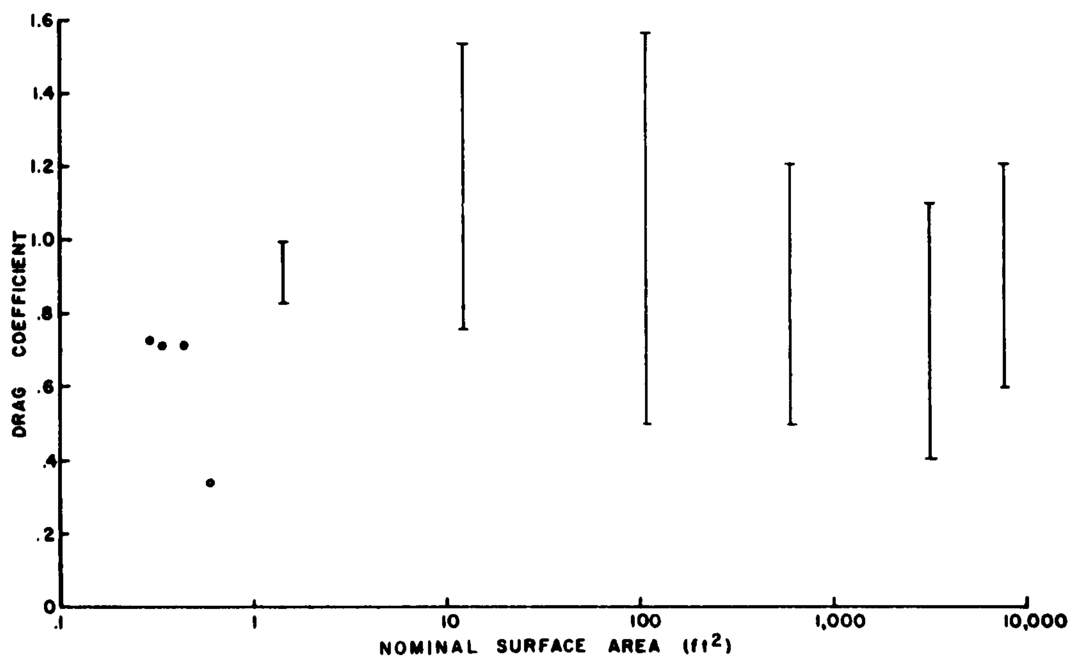

Figure 1. Circular Flat Parachute Drag Coefficient Variation

As an example, assume that a regression equation has been developed for the prediction of drag coefficient which involves only two terms--one term is a scaling variable ($\ln S_0$) and the other term is not ($\ln V$). This equation can then be used to extract from the observed data points the variation contributed due to velocity and thus allow the utilization of many more data points than if all the observed data points had to be at the same velocity. Therefore, it can be seen that the regression equation defines the variation due to scaling ($\ln S_0$) and also makes possible the utilization of data in which nonscaling variables affecting performance are also varied.

The multiple regression analysis, the theory of which is outlined in Appendix I, offers several attractive features for an analysis of this type. If the data to be analyzed by a regression technique are reasonably well distributed over the ranges of interest for the independent variables, it is possible to determine the following:

a) how closely the developed regression equation is describing the variations for the observed data points,

b) the significance of any given independent variable by using appropriate statistical techniques,

c) the functional form of a significant independent variable, and

d) the confidence limits for the predicted dependent variable.

Two methods are generally employed in choosing the regression model to represent the functional relation between the dependent and independent variables. One is to plot the sample data as 2-dimensional scatter diagrams of the dependent variable versus each of the independent variables with the other independent variables held constant to give some indication of what the individual terms of the model should be. The second method is to base the functional form of the regression model on prior knowledge and analytical considerations of the factors involved.

The first method was not adaptable for utilization in the present study since this study is based on data gathered from various sources and collected under radically different experimental conditions. It was impossible to find enough data collected under similarly controlled experimental conditions to yield meaningful 2-dimensional plots. The second method was only partially feasible since a thorough review of the pertinent literature yielded very little information applicable to the combined effects of the independent variables considered in this study.

Another source of information indicative of the independent variables and cross-products of independent variables (interactions) which are significantly affecting the dependent variable is a statistical computation procedure known as analysis of variance, a technique for analyzing the results of a designed experiment. A designed experiment is one planned in advance with the levels and combinations of levels of the independent variables chosen so that the maximum desired information on the factors may be elicited. The analysis of variance method is based on a partitioning of the variance of the observations on the dependent variable, each part measuring the variability attributed to some specific source. The method provides the quantities necessary for testing the significance of this variability. Obviously, this technique was not applicable in the present study due to the poorly distributed data on the independent variables.

It was decided to use a multiple regression technique in building a regression model by a process of trial and elimination. Application of this technique to the parachute field is believed to be unique. (Appendix I discusses the utilization of the IBM 7090 in the development of this model.) The data for this development were gathered and processed in the form of four dependent variables and approximately 12 independent variables considered to have the greatest effect on the former. A regression model for drag coefficient involving linear terms of the independent variables was first fitted but rather unsuccessfully. Other functional relations—such as models composed of the squares, reciprocals, or natural logarithms of the independent variables—were all fitted with varying degrees of success. One functional relation would fit reasonably well for one type of parachute but would not fit at all for some other type of parachute.

With the possible exception of differences in the coefficients, approximately the same functional form for a given dependent variable should fit all different types of parachutes. For each respective dependent variable, the approach employed to obtain similar functional relations for all types of parachutes was the following: Various transformations on the independent variables—transformations such as squaring, computing the reciprocal, squaring the reciprocal, extracting the square root, computing the natural logarithm, squaring the natural logarithm, and computing the reciprocal of the natural logarithm of "1" plus the variable—were performed; furthermore, cross-product terms—such as the number of gores divided by the nominal diameter and dynamic pressure times nominal surface area—were computed. Each of these terms was considered to be an "independent" variable. The correlation coefficients for all possible pairs of these "independent" variables were calculated, and the highly correlated terms were removed. Iterative multiple regression analyses were run on the remaining terms until all those not statistically significant had been deleted. The resulting functional relations are presented in Tables 1 and 2.

Table 1 presents the drag coefficient prediction equations for the five types of parachutes which had sufficient data to attempt a regression analysis. Performing the transformations on the independent variables presented in the table and then combining all terms results in a predicted drag coefficient. The degree of fit (R^2) of the tabulated (observed) values in Appendix II for the prediction equations is indicated in the parentheses. The same procedure follows for Table 2 which presents peak opening shock and filling time prediction equations for the Circular Flat and Extended Skirt parachutes. For a given dependent variable, dissimilarities in these functional relations for the various types of parachutes must be attributed to differences in the availability of data for the various parachutes.

In an effort to explain as much of the data variation as possible, several interaction terms which appear in various theoretical parachute analyses were tried in the regression models. Except for Reynolds number and Froude

Table 1

Prediction Equations for Drag Coefficient

Ribless Guide Surface (R^2 = .9253)	Extended Skirt (R^2 = .8833)	Circular Flat (R^2 = .8635)	Ringslot (R^2 = .8391)	Ribbon (R^2 = .6351)
2.7367	8.5738	14.8000	-161.0286	17.1465
$-.7895 \ln S_p$	$+.2676 \ln S_o$	$+.1316 \ln S_o$	$-.0760\ S_o$	$+3.7779 \ln S_o$
$+.0271 S_p$	$+.7067 \ln F_r$	$-11.2727 \sqrt{F_r}$	$-.1024\ W/S_o$	$+.0553\ S_o$
$-.0251 F_r$	$+.3985 F_r$	$+5.6058 \ln F_r$	$+.3796 \ln W/S_o$	$-1.8017 \sqrt{S_o}$
$-.5919\ 1/(W/S_p)$	$-.1312\ 1/F_r$	$+.7340 F_r$	$+.0007\ 1/(W/S_o)^2$	$+9.8516\ 1/S_o$
$+.0417\ 1/(W/S_p)^2$	$-.2195\ N_g/D_o$	$+1.1263 (\ln F_r)^2$	$-.7492 \ln V$	$-.0305\ 1/(W/S_o)$
$-.0008\ W/S_p$	$+.8292 \ln W/S_o$	$-.6929\ 1/(W/S_o)$	$+.0015\ V$	$+.4858 \ln V$
$61.6853\ 1/V$	$-.5600 \ln V$	$+.1852 (\ln W/S_o)^2$	$+6.1686\ N_g$	$-.4265 \ln R_e$
$+.0022\ V$	$-2.6168 \ln V$	$+.0831\ 1/(W/S_o)^2$	$+1183.7375\ 1/N_g$	$-.1601\ \lambda$
$-.0285\ 1/g^2$		$-1.1010 \ln V$		$52.5409\ 1/\lambda$
$-25.5945 (10^5)\ 1/R_e$		$-.0556\ g$		$12.2819 \ln \lambda$
$+82.6427 (10^{10})\ 1/R_e^2$		$+.2306\ 1/g$		$+5.6517 \sqrt{\lambda}$
$-.3235\ 1/(\ln/D_o)^2$		$-.0245\ 1/g^2$		$+.0089\ 1/M$
				$-.8069 (10^{-5})\ 1/M^2$

Table 2

Prediction Equations for Filling Time and Opening Shock

Filling Time		Opening Shock	
Circular Flat (R^2 = .5121)	Extended Skirt (R^2 = .4137)	Circular Flat (R^2 = .5564)	Extended Skirt (R^2 = .8695)
-.8279	-5664.0513	$210.7387 (10^2)$	$-1213.9166 (10^2)$
$+3142.5799\ \rho D_o/V^9$	$+.3910\ 1/\rho$	$-4757.9144 (10^3)\ \rho$	$+9771.1968 (10) \ln N_g$
$-1881.1376 (10^2)\ \rho^2$	$+1573.1123 (10^7)\ 1/Re$	$+9780.2371 (10^3)\ \rho D_o/V^9$	$+2861.5800\ 1/M$
$+.0029\ V$	$+474.2279 \ln Re$	$-366.7599 (10^2)\ 1/\ln(1+q)$	$-2520.9976 (10) \ln S_o$
$-.0010\ 1/\rho$	$+467.0649 \ln \rho$	$-7.3409\ S_o$	$+1081.3135 (10^3)\ 1/N_g$
$+.0041\ \lambda$	$-.3352 (10^{-4})\ 1/\rho^2$	$+3.9308 (10^{-5})\ Re$	$-51.8082\ 1/M^2$
$+303.8672\ S_v/S_o$	$-5664.4910 (10^{13})\ 1/Re^2$	$-8.1269\ \lambda$	$+1238.1923 (10) \ln M$
$+.3037 (10^{-6})\ 1/\rho^2$	$-1694.6732 (10^2)\ \rho$		$-947.1344\ N_g$
$+35.3660\ 1/\lambda$	$-.3889 (10^{-5})\ Re$		$+4.7390\ S_o$
	$-.7334\ q$		$-4028.1048 (10)\ N_g/D_o$
	$+1136.0969 (10^4)\ \rho^2$		$-4051.9106 (10^6)\ 1/S_o^2$
	$+17.4472 \ln q$		$-138.1699\ 1/(W/S_o)^2$
	$+.0015\ q^2$		
	$-3783.4468 (10)\ \rho D_o/V^9$		
	$+3.8789\ Fr$		
	$+16.5306 \ln S_o$		
	$+114.3176\ 1/Fr$		

number, however, the only interaction term found to be significant was $\frac{\rho D_0}{V^{.9}}$ which was for filling time. This does not necessarily indicate that these other variables may not be significant; for this could have resulted from the observed data used in the regression analyses. It is of interest to note the b value (coefficient) for $\frac{\rho D_0}{V^{.9}}$ for the Circular Flat parachute listed in Table 2. This value with its associated 95-percent confidence limits will encompass the constant, $\frac{8}{\rho_0}$ (ρ_0=.002378), which is given in the "USAF Parachute Handbook" (reference 30).

It was initially anticipated that the same variables with similar functional forms and possibly just slightly different coefficients would be significant for all the parachute types. That the regression models did not substantiate this anticipation was apparently due to the poor distribution of the available data. Nevertheless, it is believed that adequate data will prove the hypothesis. At least it should be noted that the scaling variables ($\ln S_0$, Fr, $\ln Fr$, Fr, $\left[\ln Fr\right]^2$) for the Circular Flat parachute drag coefficient are similar to the scaling variables ($\ln S_0$, $\ln Fr$, Fr, $1/Fr$) for the Extended Skirt parachute drag coefficient. Furthermore, these two regression models were obtained from larger amounts of data than were available for the other types of parachutes.

D. Scaling Equation Theory

If the prediction equations as presented in Tables 1 and 2 are used, the scaling equations can be derived as follows: The only variables of interest in these prediction equations are the scaling variables; therefore, for practical purposes the other variables are disregarded. The reasoning that substantiates this statement is that a scale effect is interpreted as a change in the dependent variable (drag coefficient, etc.) due to a change in only the independent scaling variables. As a change denotes an increment, the non-scaling variables can be eliminated since they don't vary through this interval. Assuming the prediction equation to have five terms of which the first two and the last are scaling variables ($b_1 X_{1j}$, $b_2 X_{2j}$ and $b_5 X_{5j}$),

$$\hat{Y}_j = d_0 + b_1 X_{1j} + b_2 X_{2j} + b_3 X_{3j} + b_4 X_{4j} + b_5 X_{5j},$$

then, the incremental change in the dependent variable, as predicted by the regression equation, is

$$\hat{Y}_2 - \hat{Y}_1 = b_1 (X_{12} - X_{11}) + b_2 (X_{22} - X_{21}) + b_5 (X_{52} - X_{51}) = b_1 K_1 + b_2 K_2 + b_5 K_5$$

Thus, $(\hat{Y}_2 - \hat{Y}_1)$ is the incremental change in drag coefficient, filling time, or opening shock caused by a change in scale and this derived equation is then the scaling equation.

With the change in the dependent variable known, it is also desirable to determine the confidence limits for this change. To predict confidence limits, the variance of the predicted change must be estimated.

To estimate the variance of the difference between two predicted mean values of the dependent variable when one or more of the independent variables remains constant, let it again be assumed for purposes of illustration that the fitted regression equation has five terms:

$$\hat{Y} = d_0 + b_1 X_{1j} + b_2 X_{2j} + b_3 X_{3j} + b_4 X_{4j} + b_5 X_{5j}$$

The estimate of the variance of $(\hat{Y}_2 - \hat{Y}_1)$ is desired when, for example, X_3 and X_4 remain constant, i.e., $X_{31} = X_{32}$ and $X_{41} = X_{42}$.

Now,

$$\text{Var } (\hat{Y}_2 - \hat{Y}_1) = E\left[(\hat{Y}_2 - \hat{Y}_1)^2\right] - \left[E(\hat{Y}_2 - \hat{Y}_1)\right]^2 ,$$

and $$\hat{Y}_2 - \hat{Y}_1 = b_1 (X_{12} - X_{11}) + b_2 (X_{22} - X_{21}) + b_5 (X_{52} - X_{51}) = b_1 K_1 + b_2 K_2 + b_5 K_5$$

Thus,

$$\text{Var } (\hat{Y}_2 - Y_1) = E\left[(b_1 K_1 + b_2 K_2 + b_5 K_5)^2\right] - \left[E\ (b_1 K_1 + b_2 K_2 + b_5 K_5)\right]^2$$

Considering these two terms separately,

$$E\left[(b_1 K_1 + b_2 K_2 + b_5 K_5)^2\right] = E\left[b_1^2 K_1^2 + b_2^2 K_2^2 + b_5^2 K_5^2 + 2 b_1 b_2 K_1 K_2 + 2 b_1 b_5 K_1 K_5 + 2 b_2 b_5 K_2 K_5\right]$$

$$= K_1^2\left[\sigma_1^2 + \beta_1^2\right] + K_2^2\left[\sigma_2^2 + \beta_2^2\right] + K_5^2\left[\sigma_5^2 + \beta_5^2\right]$$

$$+ 2 K_1 K_2\left[\sigma_{12} + \beta_1 \beta_2\right] + 2 K_1 K_5\left[\sigma_{15} + \beta_1 \beta_5\right] + 2 K_2 K_5 \left[\sigma_{25} + \beta_2 \beta_5\right]$$

and

$$\left[E(b_1 K_1 + b_2 K_2 + b_5 K_5)\right]^2 = \left[K_1 \beta_1 + K_2 \beta_2 + K_5 \beta_5\right]^2 = K_1^2 \beta_1^2 + K_2^2 \beta_2^2 + K_5^2 \beta_5^2$$

$$+ 2 K_1 K_2 \beta_1 \beta_2 + 2 K_1 K_5 \beta_1 \beta_5 + 2 K_2 K_5 \beta_2 \beta_5 .$$

Taking the difference of these two expressions yields

$$\text{Var } (\hat{Y}_2 - \hat{Y}_1) = K_1^2 \sigma_1^2 + K_2^2 \sigma_2^2 + K_5^2 \sigma_5^2 + 2 K_1 K_2 \sigma_{12} + 2 K_1 K_5 \sigma_{15} + 2 K_2 K_5 \sigma_{25} ,$$

where $\sigma_i^2 = \text{Var}(b_i)$ and $\sigma_{ij} = \text{Cov}(b_i b_j)$

would be estimated by

$$S^2_{\hat{Y}_2 - \hat{Y}_1} = S_E^2\left[K_1^2 C_{11} + K_2^2 C_{22} + K_5^2 C_{55} + 2 K_1 K_2 C_{12} + 2 K_1 K_5 C_{15} + 2 K_2 K_5 C_{25}\right]$$

where c_{ii} and c_{ij} are defined, as before, to be elements of the inverse matrix C .

The predicted change due to scaling with associated 95-percent confidence limits is then,

$$(\hat{Y}_2 - \hat{Y}_1) \pm 1.96 \ S_{\hat{Y}_2 - \hat{Y}_1} .$$

E. Limitations of Regression Models for Development of Scaling Equations

There are several reasons why the regression equations, other than the equations for the Circular Flat and Extended Skirt parachutes, were not used to develop scaling equations. Presented in Table 3 are the ranges of the independent variables of the observed data. If the regression equations are used for prediction purposes for values of the independent variables outside these ranges, a correct result would be purely accidental. However, not only is it necessary to consider the range, but also the distribution of the observed data with respect to the independent variables in this range. Of primary importance for this investigation is the distribution with respect to canopy nominal surface area. These distributions for surface area are presented in Figures 2 through 8 and are typical of the distributions for the other independent variables. As can be seen, the ranges for the independent variable presented in Table 3 can be quite misleading since only extreme values are indicated. It is, therefore, necessary to consider the distribution of observed data points for every scaling variable before the scaling equations can be developed and used.

Table 3
Ranges of Independent Variables

Parachute Type	Dependent Variables	S_o ($ft.^2$)	l_s/D_o	N_g/D_o	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2$" H_2O (ft^3/ft^2-min)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr
Flat Circular	C_D	0.196 to 17,671.5	0.816 to 1.810	1.00 to 20.70	0.0 to 1.3	0.0 to 0.25	0 to 426	0.188 to 51.60	10.4 to 233.8	0.12 to 60.0	0.1383 to 28.650	.0094 to .2445	.229 to 31.1
	t_f and F_o	452.0 to 804.0	0.700 to 0.850	* 1.0	* 0	0.0 to .01	60 to 260	0.256 to 0.499	168.0 to 467.6	27.7 to 204.4	20.7 to 70.07	.1514 to .4236	5.45 to 15.58
Extended Skirt	C_D	1.910 to 5319.73	0.600 to 1.400	0.5007 to 17.96	0.0 to 0.1	0.0 to 0.1	10 to 275	0.119 to 10.33	9.8 to 111.7	0.108 to 12.55	0.129 to 18.053	0.0088 to 0.100	.374 to 15.75
	t_f and F_o	715.6 to 5230.0	0.699 to 1.000	0.500 to 0.9376	0.0 to 0.09	0.0 to 0.008	30 to 135	0.226 to 0.736	150.0 to 504.1	24.9 to 194.8	30.58 to 280.0	0.1340 to 0.4681	4.274 to 15.05
Ribbon	C_D	3.66 to 129.2	1.000 to 1.400	1.345 to 7.412	0 to 1.430	0 to 0.010	** 9.7 to 30.0	0.078 to 70.53	9.9 to 514.0	0.108 to 295.0	0.747 to 35.40	0.0087 to 0.4627	0.511 to 30.93
Ring Slot	C_D	48.0 to 920.8	1.0 to 1.535	.3346 to 1.964	No Value	0.0 to 0.008	** 9.82 to 17.80	0.10 to 48.20	9.8 to 584.0	0.111 to 364.0	0.727 to 25.55	.0088 to 0.518	0.503 to 36.83
Guide Surface (Ribless)	C_D	0.615 to 48.10	1.0 to 1.72	1.278 to 13.54	0 to 13.2	0 to [illegible]	10 to 275	0.161 to [illegible]	10.8 to 516.0	0.119 to 304.0	0.469 to 19.90	0.009 to 0.471	0.629 to 45.0

*Note. No range ** Geometric porosity given in per cent.

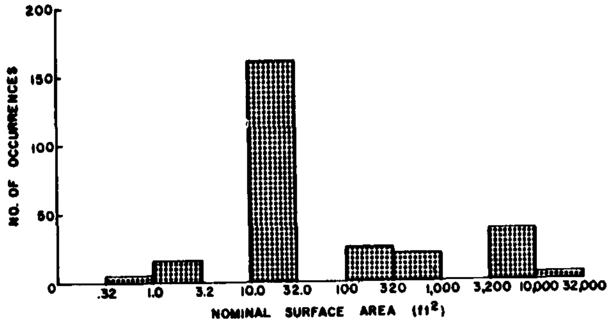

Figure 2
Circular Flat Drag Coefficient Data Distribution

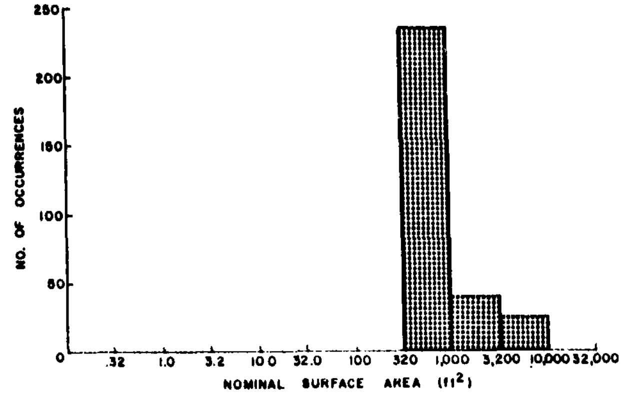

Figure 5
Extended Skirt Filling Time and Opening Shock Data Distribution

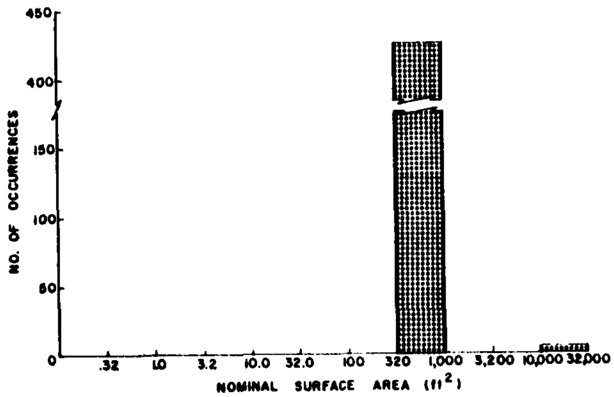

Figure 3
Circular Flat Filling Time and Opening Shock Data Distribution

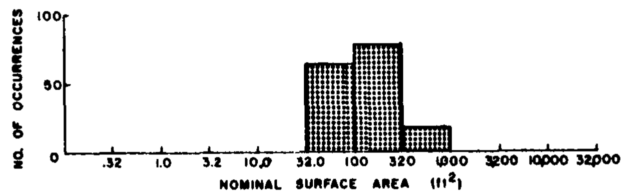

Figure 6
Ringslot Drag Coefficient Data Distribution

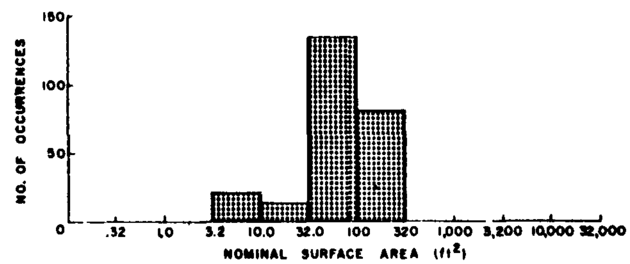

Figure 7
Ribbon Drag Coefficient Data Distribution

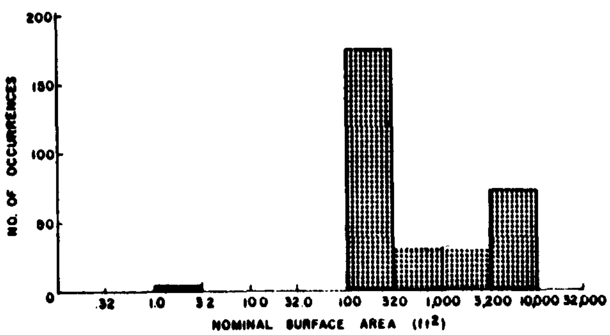

Figure 4
Extended Skirt Drag Coefficient Data Distribution

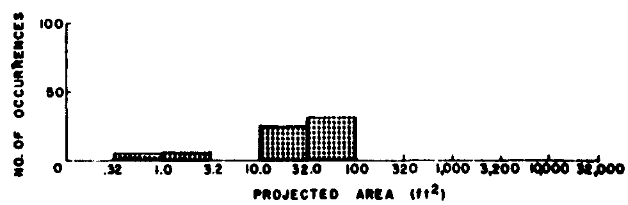

Figure 8
Ribless Guide Surface Drag Coefficient Data Distribution

As an obvious example of why a scaling equation was not developed, virtually all of the collected data for filling time and opening shock for the Circular Flat parachute fell in one area range. Therefore, any predictions involving canopy areas outside this range would be unwarranted extrapolations. It should also be noted with reference to Figure 4 that data for the Extended Skirt parachute drag coefficient was nil for the smaller nominal surface areas. For this reason, the restriction on the use of the developed scaling equation in this canopy area range should be carefully observed. Also, reference to Appendix II will show that the distribution of the observed data for Ng / D_0 for the Extended Skirt is for practical purposes much narrower than indicated in Table 3.

The most subtle and, consequently, most difficult reason to recognize, which prevents the development of scaling equations from most of the regression models, is the warped or unreasonable surface shape predicted by the regression models. In other words, it is very possible for the regression model to have a very high multiple correlation (R^2), but due to the poor distribution of the observed data, be capable of predicting accurately only for the observed data points.

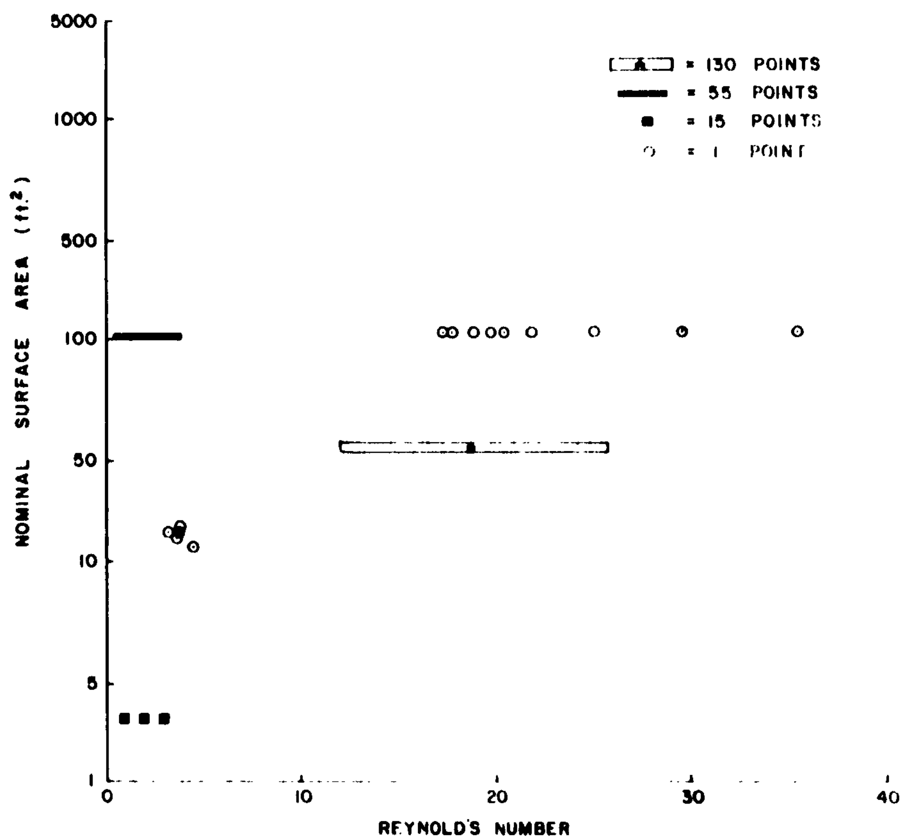

Figure 9. Ribbon Parachute Observed Data Distribution for Scaling Variables

To clarify this point, the regression model for the Circular Flat Ribbon parachute will be used as an example. Figure 9 presents the observed data distribution for the Ribbon parachute as a function of the scaling variables, canopy surface area, and Reynolds number. These variables were chosen to demonstrate the data distribution since both were significant scaling variables as predicted by the Ribbon parachute regression model. Figure 9 shows that the observed data is very highly concentrated in three or four regions. For comparison purposes, Figure 10 presents the observed data distribution for the Circular Flat parachute for its significant scaling variables, canopy surface area, and Froude number. The Circular Flat parachute data can be seen to be much more evenly distributed as a function of its scaling variables than the Ribbon parachute data is.

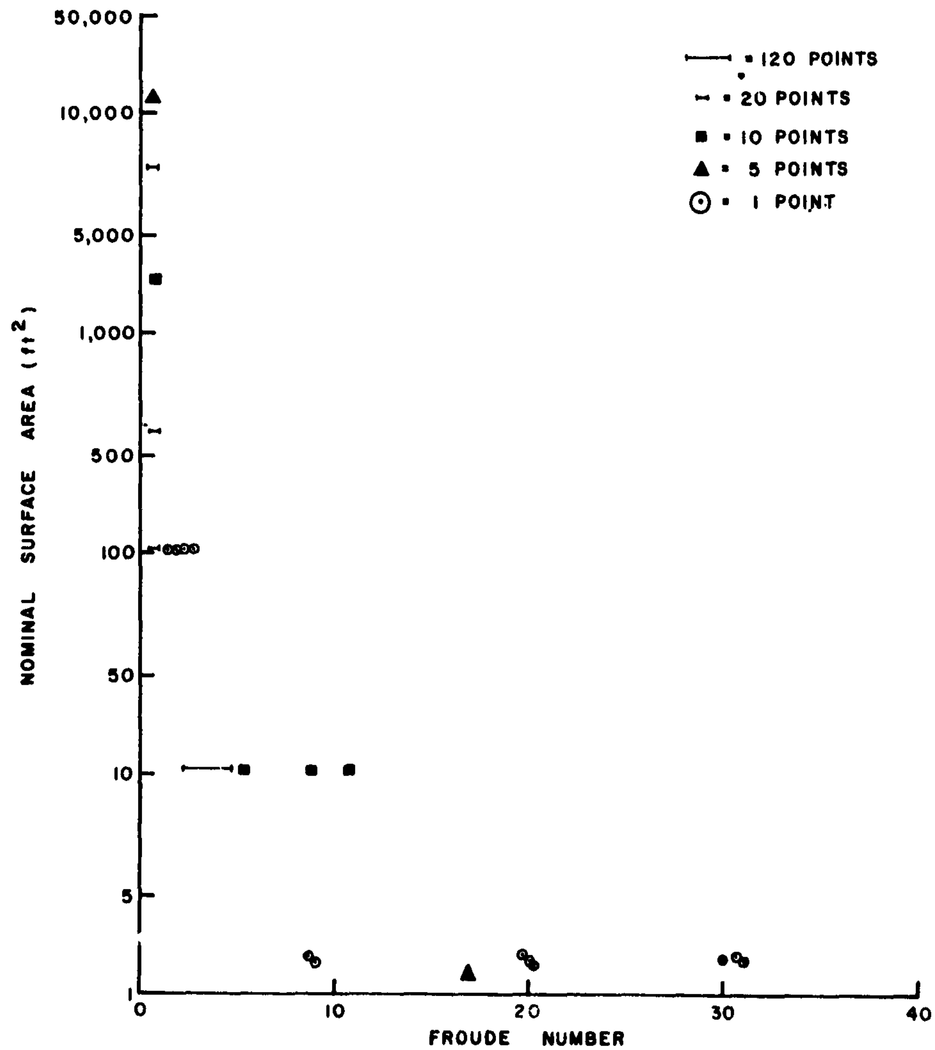

Figure 10. Circular Flat Observed Data Distribution for Scaling Variables

To demonstrate the effect that the difference in data distribution can have, assume that the drag coefficient is predicted for both types of parachutes for a 75-square foot surface area, 10^7 Reynolds number, and 1.35 Froude number (Reynolds number and Froude number are compatible so that the same condition is being investigated for both parachute types). It will be found that the regression model for the Circular Flat parachute will predict very well and the regression model for the Ribbon parachute will predict very poorly. It can be seen by reference to Figures 9 and 10, however, that the point at which the drag coefficient prediction is being attempted falls among clusters of observed data for both parachute types. To demonstrate the cause of this apparent paradox, the Ribbon parachute regression model can be differentiated with respect to canopy surface area, which yields,

$$\frac{\partial C_D}{\partial S_0} = .0553 + \frac{3.7799}{S_0} - \frac{1.8017}{2\sqrt{S_0}} - \frac{9.8516}{S_0^2}$$

Evaluation of this differential through a canopy surface area range of 40 feet^2 to 120 feet^2 yields the slopes for the predicted surface as presented in Figure 11. Since the observed data for the Ribbon parachute is very heavily concentrated around the canopy surface areas of 55 feet^2 and 110 feet^2, it can be surmised, with reference to Figure 11, that the prediction surface is passing through the observed data at these points and dropping down to an inflection point at a canopy surface of 75 feet^2. This in actuality is what is occurring and this is demonstrated in the 3-dimensional sketch of the predicted surface presented in Figure 12. The observed data points are represented by the dots and the prediction by the cross in this figure. It can be seen from the sketch of this surface, how a regression equation can fit the observed data very well (high R^2) and still not be appropriate for prediction purposes at any other points. This is probably the most forceful argument that can be made for the necessity of a well designed experiment which results in a favorable distribution of observed data points.

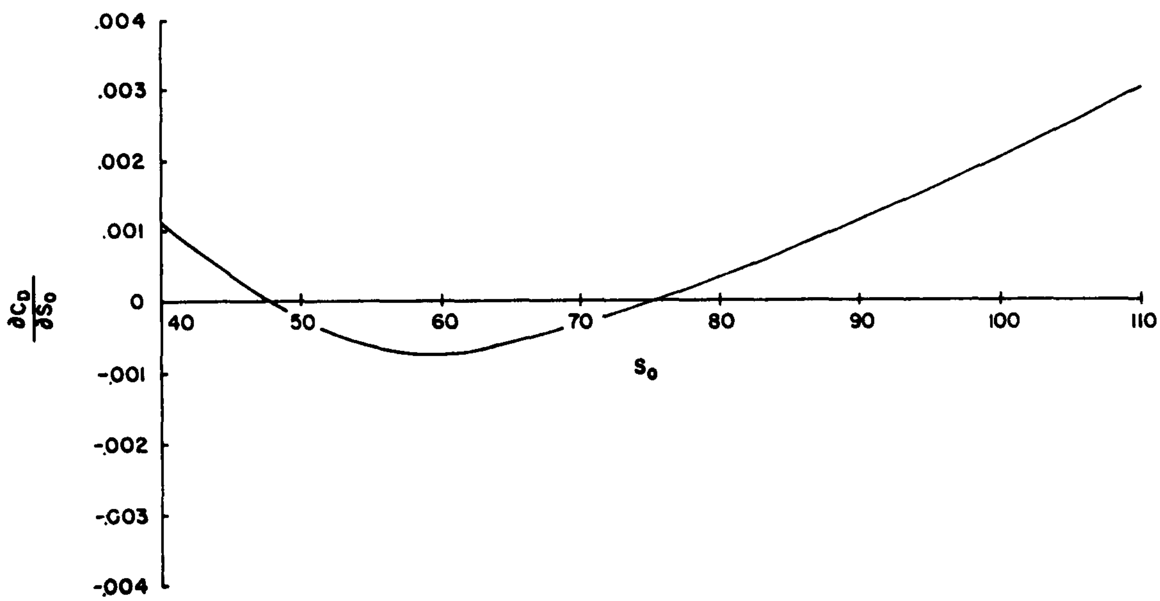

Figure 11. Slope of Drag Coefficient Surface for Ribbon Parachute

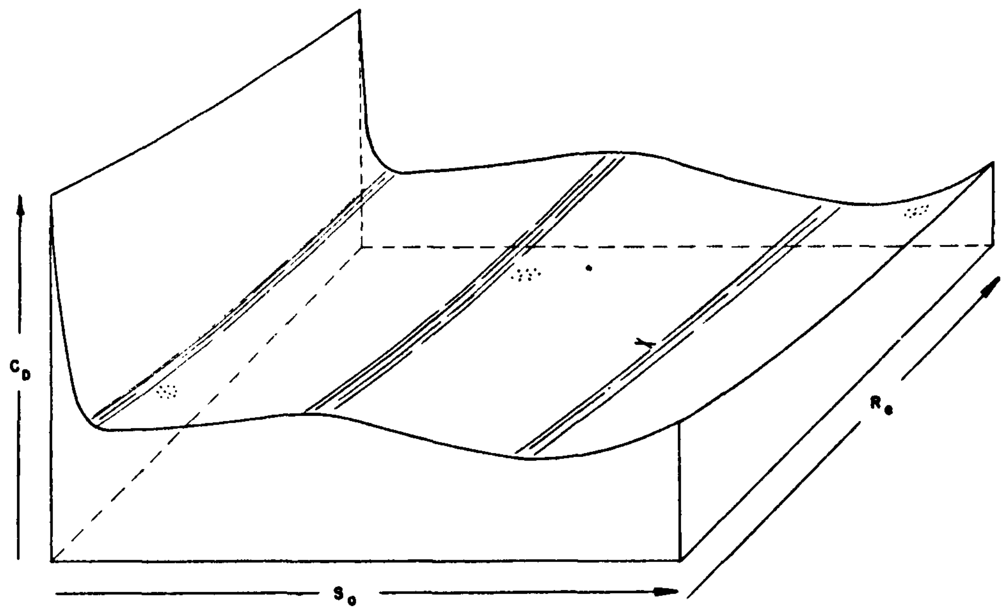

Figure 12. Drag Coefficient Surface Predicted by Regression Equation

F. Scaling Equations for Circular Flat and Extended Skirt Parachutes Drag Coefficient

This subsection presents the information necessary to derive the scaling effects and associated confidence intervals on drag coefficient for the Circular Flat and Extended Skirt parachutes and gives an example using the Circular Flat parachute. The reasons for selecting only these two regression models to develop scaling equations are as explained previously.

Presented in Table 4 are the scaling variables and coefficients for the Circular Flat and Extended Skirt parachutes which may vary for a change in scale if the other independent variables are held constant. Table 5 presents the associated c_{ii} and c_{ij} values.

Table 4

Scaling Variables and Coefficients

Flat Circular		Extended Skirt*	
Variable	b_i	Variable	b_i
$\ln S_o$	0.1316	$\ln S_o$	0.2676
$\sqrt{F_r}$	-11.2727	$\ln F_r$	0.7067
$\ln F_r$	5.6058	F_r	0.3985
F_r^2	0.7340	$1/F_r$	-0.1312
$(\ln F_r)^2$	1.1263	N_g/D_o	-0.2195

*Information to be used only in the nominal surface canopy area range of 100 feet^2 to 5300 feet^2.

Table 5

Inverse Matrix, C, Values

Flat Circular		Extended Skirt	
C_{11} = 0.2257	C_{25} = -14.9632	C_{11} = 1.6231	C_{25} = 1.6305
C_{12} = -2.8230	C_{33} = 41.9722	C_{12} = 6.9017	C_{33} = 1.0708
C_{13} = 2.1354	C_{34} = 5.0599	C_{13} = -0.2483	C_{34} = -0.9737
C_{14} = 0.1666	C_{35} = 7.9017	C_{14} = 0.1911	C_{35} = -0.6395
C_{15} = 0.3342	C_{44} = 0.7060	C_{15} = 0.1528	C_{44} = 1.1988
C_{22} = 148.9704	C_{45} = 0.9812	C_{22} = 32.6942	C_{45} = 0.5544
C_{23} = -76.4048	C_{55} = 1.5620	C_{23} = -2.7609	C_{55} = 0.3892
C_{24} = -10.0956		C_{24} = 2.7680	
S^2_E = 0.006508		S^2_E = 0.003025	

To predict the change in drag coefficient for the Circular Flat parachute for a change in size from a nominal diameter of two feet to a nominal diameter of fifty feet, assuming velocity equal to 32.2 feet/second, the procedure is as follows:

First, with $D_0 = 50$ and $D_0 = 2$, the variables listed in Table 4 would yield the following values:

D	50	2
$\ln S_0$	7.58248	1.14473
$\sqrt{F_r}$	.89586	2.00312
$\ln F_r$	-.21995	1.38941
F_r	.80256	4.01249
$(\ln F_r)^2$	.04838	1.93046

where $F_r = \sqrt{\frac{V^2}{gD_0}}$. Now,

$$\Delta C_D = \hat{Y}_1 - \hat{Y}_2 = b_1 K_1 + b_2 K_2 + b_3 K_3 + b_4 K_4 + b_5 K_5$$

$K_1 = (X_{12} - X_{11})$

where $X_{12} = 7.58248$
and $X_{11} = 1.14473$

$K_2 = (X_{22} - X_{21})$

where $X_{22} = .89586$
and $X_{21} = 2.00312$

$K_3 = (X_{32} - X_{31})$

where $X_{32} = -.21995$
and $X_{31} = 1.38941$

$K_4 = (X_{42} - X_{41})$

where $X_{42} = .80256$
and $X_{41} = 4.01249$

$K_5 = (X_{52} - X_{51})$

where $X_{52} = .04838$
and $X_{51} = 1.93046$

$$\begin{aligned}\Delta C_D = {} & 0.1316\,(7.58248 - 1.14473) - 11.2727\,(0.89586 - 2.00312) \\ & + 5.6058\,(-0.21995 - 1.38941) + 0.7340\,(0.80256 - 4.01249) \\ & + 1.1263\,(0.04838 - 1.93046)\end{aligned}$$

$$\Delta C_D = .84721 + 12.48181 - 9.02175 - 2.35609 - 2.11979$$

$$\Delta C_D = -.1686$$

which is then the change in drag coefficient for a change in nominal diameter from two feet to fifty feet.

To estimate the variance of this change,

$$S^2_{\hat{Y}_2 - \hat{Y}_1} = S^2_E \Big[K_1^2 c_{11} + K_2^2 c_{22} + K_3^2 c_{33} + K_4^2 c_{44} + K_5^2 c_{55} + 2K_1K_2c_{12} + 2K_1K_3c_{13}$$
$$+ 2K_1K_4c_{14} + 2K_1K_5c_{15} + 2K_2K_3c_{23} + 2K_2K_4c_{24} + 2K_2K_5c_{25} + 2K_3K_4c_{34}$$
$$+ 2K_3K_5c_{35} + 2K_4K_5c_{45}\Big]$$

$$S^2_{\hat{Y}_2 - \hat{Y}_1} = .006508 \Big[(6.43775)^2(0.2257) + (1.10726)^2(148.9704)$$
$$+ (-1.60936)^2(41.9722) + (3.20993)^2(0.7060) + (-1.88208)^2(1.5620)$$
$$+ 2(6.43775)(1.10726)(2.8230) + 2(6.43775)(-1.60936)(2.1354)$$
$$+ 2(6.43775)(3.20993)(0.1666) + 2(6.43775)(-1.88208)(0.3342)$$
$$+ 2(-1.10726)(-1.60936)(-76.4048) + 2(-1.10726)(3.20993)(10.0956)$$
$$+ 2(1.10726)(1.88208)(14.9632) + 2(1.60936)(-3.20993)(5.0599)$$
$$+ 2(1.60936)(1.88208)(7.9017) + 2(-3.20993)(-1.88208)(0.9812)\Big]$$

$$S^2_{\hat{Y}_2 - \hat{Y}_1} = .006508 \big[.094675\big]$$

$$S^2_{\hat{Y}_2 - \hat{Y}_1} = .000616$$

The standard deviation is then $\sqrt{.000616}$ which is equal to 0.02482 and the expected change in drag coefficient with associated 95-percent confidence limits is $-.1686 \pm 1.96\ (0.02482)$ or $-.1686 \pm 0.04869$. This is shown in Figure 13 as the squares and circle along with the expected change in drag coefficient and 95 percent confidence limits for any change in nominal diameter between two feet and one hundred feet.

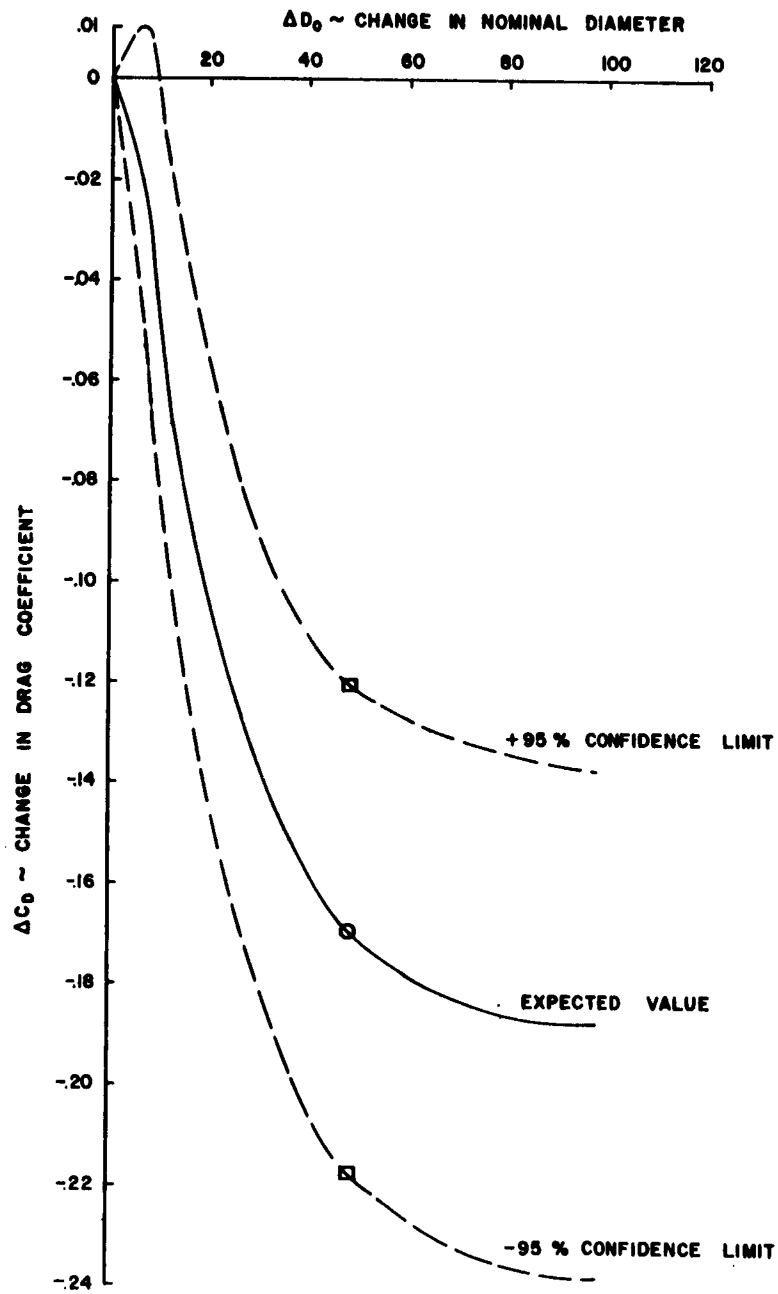

Figure 13. Incremental Change in Drag Coefficient Due to Scaling

SECTION III

CONCLUSIONS

1. The development of scaling equations by statistical techniques is feasible.

2. Scaling equations were developed for drag coefficient for the Circular Flat and Extended Skirt parachute types which apparently yield reasonable predictions although the Extended Skirt scaling equation is rather limited in range of application.

3. The distribution of the observed data is probably the most significant single factor influencing the development of accurate scaling equations.

4. A high multiple correlation (R^2) for the regression model cannot be relied upon as a satisfactory condition for permitting the development of accurate scaling equations.

5. Variables, such as suspension line length, porosity, etc., which are known to affect parachute performance, did not necessarily appear statistically significant for the regression analysis due to the poor distribution of available data.

6. The collection of data from many varied sources led to less accurate equations than data gathered from one set of tests.

SECTION IV

RECOMMENDATIONS

As noted previously, many areas in this investigation have insufficient or questionable data. The developed scaling equations, therefore, can be considered only as preliminary media in the development of basic equations. Scrutiny of the developed equations and data distribution charts and tables in Section II and the data summary tables in Appendix II reveals the lack of data in several areas. There is practically no usable information defining any parachute's stability; only the Solid Flat Circular and Extended Skirt types of parachutes have usable peak opening shock and filling time data. The Conical Ribbon parachute data are virtually nonexistent. Since all types of parachutes need additional information to some degree, the following recommendations are made.

1. Future testing should be directed toward filling the existing voids in the available data. The less the variation of parameters other than the scaling variables, the more desirable this testing will be.

2. Initial concentration toward defining the scaling equations for only one type of parachute would be desirable, since it is felt that the scaling equations for all common types of parachutes will be similar.

3. All future testing should be conducted according to a specific statistical design of experiment in order to yield maximum use of the resultant test data.

4. A consistent method should be established for the definition of parachute stability. At present, it is impossible to correlate the period and the amplitude of parachute oscillation (also gliding and coning) under free-fall conditions with wind tunnel tests which define pitching moment at angle of attack. Therefore, until this problem is solved, pitching moment at angle of attack will probably mean very little except in the general sense that the parachute is stable or unstable over a given range. For an analysis of parachute scaling effects for stability, this consistent definition is almost mandatory.

Looking further into the future, the following recommendations are made:

1. The range of applicability of the scaling equations should be extended to include a much broader operating regime (altitude and velocity).

2. The effects of variables other than scaling variables—for example, ribbon spacing—should be investigated so that a scale model test can be used to evaluate parachute performance without requiring unnecessarily complicated fabrication procedures.

3. The effects of different types of testing—such as free-fall, wind tunnel, and rocket sled—should be evaluated.

BIBLIOGRAPHY

This bibliography is a comprehensive listing of the references pertinent to the subject of this report. All available literature relating to the parachute research program was reviewed before the preparation of the bibliography.

The references have been separated into two sections: Part I lists the references which provided data used in the program analysis, and Part II presents the references which did not offer usable data.

The items are arranged either alphabetically by author or sequentially by reference number when anonymous. As many of the publications are in the general or special collections of ASTIA, they are identified accordingly.

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APPENDIX I

REGRESSION ANALYSIS AND COMPUTER PROGRAM

A. General Least Squares Multiple Regression

A general least squares multiple regression analysis with k fixed variates postulates that some variable or characteristic, Y, is related to or depends on certain other variables or characteristics, $X_1, X_2, \cdots, X_k$, by means of the general linear relation (regression model)

$$Y = \delta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k ,$$

where $X_i (i = 1, 2, \cdots, k)$ may take any functional form of the independent variable; e.g., natural log, inverse, etc. Obtaining estimates of the regression coefficients by the method of least squares consists of obtaining an expression

$$\hat{Y} = d_0 + b_1 X_1 + b_2 X_2 + \cdots b_k X_k$$

such that the error sum of squares, i.e., the sum of the deviations squared of the observed Y from the predicted or fitted $\hat{Y}$, $SSE = \sum_{j=1}^{n} (Y_j - \hat{Y}_j)^2$, be a minimum, where there are n observations or data points $(n \geq k + 1)$.

In order that tests of hypotheses involving the β's and the overall regression may be made and confidence intervals for the β's and predicted Y values computed, the following assumptions concerning the measured variables must be made:

(i) the X's are measured with negligible error and, therefore, are regarded as fixed constants which may be chosen at the discretion of the experimenter;

(ii) for a given set of X's, the possible Y values are normally and independently distributed with mean, $\mu_Y = \delta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k$, and variance, σ_E^2;

(iii) the variance of Y for all sets of X's is identically σ_E^2

It must be emphasized that this postulated relationship between Y and the X's is not necessarily a causal one, but is rather a relationship which may be used for predictive or analytic purposes.

B. The Method of Least Squares

To minimize the error sum of squares, the following procedure is employed. Write

$$SSE = \sum (Y - \hat{Y})^2 = \sum (Y - d_0 - b_1 X_1 - b_2 X_2 - \cdots - b_k X_k)^2 ,$$

where the index of summation has been omitted for simplicity of notation. Partially differentiate SSE with respect to each of the parameters to be estimated and equate these partial derivatives to zero:

$$\frac{\partial SSE}{\partial d_0} = 2\sum(Y-d_0-b_1X_1-b_2X_2-\cdots-b_kX_k)(-1)=0$$

$$\frac{\partial SSE}{\partial b_1} = 2\sum(Y-d_0-b_1X_1-b_2X_2-\cdots-b_kX_k)(-X_1)=0$$

$$\frac{\partial SSE}{\partial b_2} = 2\sum(Y-d_0-b_1X_1-b_2X_2-\cdots-b_kX_k)(-X_2)=0$$

$$\vdots$$

$$\frac{\partial SSE}{\partial b_k} = 2\sum(Y-d_0-b_1X_1-b_2X_2-\cdots-b_kX_k)(-X_k)=0$$

Multiply the first equation by 1/2, perform the indicated summations term by term, and solve for d_0 :

$$d_0=\bar{Y}-b_1\bar{X}_1-b_2\bar{X}_2-\cdots-b_k\bar{X}_k,$$

where $\bar{Y},\bar{X}_1,\bar{X}_2,\cdots,\bar{X}_k$ are the arithmetic means. Multiply the remaining equations by 1/2, perform the indicated summations term by term, and transfer the first sum in each equation to the right side:

$$\begin{aligned}
d_0\sum X_1+b_1\sum X_1^2+b_2\sum X_1X_2+\cdots+b_k\sum X_1X_k&=\sum X_1Y\\
d_0\sum X_2+b_1\sum X_2X_2+b_2\sum X_2^2+\cdots+b_k\sum X_2X_k&=\sum X_2Y\\
&\vdots\\
d_0\sum X_k+b_1\sum X_kX_1+b_2\sum X_kX_2+\cdots+b_k\sum X_k^2&=\sum X_kY
\end{aligned}$$

Substitute the expression for d_0 in each of these equations and group similar terms:

$$\begin{aligned}
b_1(\sum X_1^2-\bar{X}_1\sum X_1)+b_2(\sum X_1X_2-\bar{X}_2\sum X_1)+\cdots+b_k(\sum X_1X_k-\bar{X}_k\sum X_1)&=(\sum X_1Y-\bar{Y}\sum X_1)\\
b_1(\sum X_2X_1-\bar{X}_1\sum X_2)+b_2(\sum X_2^2-\bar{X}_2\sum X_2)+\cdots+b_k(\sum X_2X_k-\bar{X}_k\sum X_2)&=(\sum X_2Y-\bar{Y}\sum X_2)\\
&\vdots\\
b_1(\sum X_kX_1-\bar{X}_1\sum X_k)+b_2(\sum X_kX_2-\bar{X}_2\sum X_k)+\cdots+b_k(\sum X_k^2-\bar{X}_k\sum X_k)&=(\sum X_kY-\bar{Y}\sum X_k)
\end{aligned}$$

These equations thusly obtained by the method of least squares are commonly known as the normal equations.

Particular note should be made of the quantities in parentheses. These quantities are the corrected sums of squares or sums of products, i.e.,

$$(\sum X_i X_j - \bar{X}_i \sum X_j) = (\sum X_i X_j - \frac{\sum X_i \sum X_j}{n}) = \sum (X_i - \bar{X}_i)(X_j - \bar{X}_j) = (\sum X_j X_i - \bar{X}_j \sum X_i),$$

$$(i, j = 1, 2, \cdots, k)$$

and

$$(\sum X_i Y - \bar{Y} \sum X_i) = (\sum X_i Y - \frac{\sum Y \sum X_i}{n}) = \sum (X_i - \bar{X})(Y - \bar{Y}), (i = 1, 2, \cdots, k).$$

Denoting the corrected sums of squares and sums of products of the X's and Y's by a_{ij} and a_{iy}, respectively, the normal equations take the form

$$\begin{aligned} a_{11} b_1 + a_{12} b_2 + \cdots + a_{1k} b_k &= a_{1y} \\ a_{21} b_1 + a_{22} b_2 + \cdots + a_{2k} b_k &= a_{2y} \\ \vdots \qquad & \quad \vdots \\ a_{k1} b_1 + a_{k2} b_2 + \cdots + a_{kk} b_k &= a_{ky} \end{aligned}$$

where, as indicated above, $a_{ij} = a_{ji}$, $(i, j, = 1, 2, \cdots k)$.

To obtain the least squares estimates $b_1, b_2, \cdots, b_k$ of the regression coefficients $\beta_1, \beta_2, \cdots \beta_k$, it is required to solve the system of normal equations for $b_1, b_2, \cdots, b_k$, and then substitute these values into the expression for d_0 to obtain the complete prediction equation $\hat{Y}$.

C. <u>Estimation of the Regression Coefficients and Tests of Significance</u>

Expressing the normal equations in matrix notation where

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1k} \\ a_{21} & a_{22} & \cdots & a_{2k} \\ \vdots & \vdots & & \vdots \\ a_{k1} & a_{k2} & \cdots & a_{kk} \end{bmatrix}, \quad \underline{b} = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_k \end{bmatrix}, \text{ and } \underline{G} = \begin{bmatrix} a_{1y} \\ a_{2y} \\ \vdots \\ a_{ky} \end{bmatrix}$$

yields $A \underline{b} = \underline{G}$.

Multiplication by A^{-1} produces

$$\begin{aligned} A^{-1} A \underline{b} &= A^{-1} \underline{G} \\ I \underline{b} &= A^{-1} \underline{G} \\ \underline{b} &= A^{-1} \underline{G}, \end{aligned}$$

where A^{-1} is the inverse of the A matrix and I denotes the identity matrix.

Denoting the elements of the inverse of the A matrix as

$$C = A^{-1} = \begin{bmatrix} C_{11} & C_{12} \cdots & C_{1k} \\ C_{21} & C_{22} \cdots & C_{2k} \\ & & \\ C_{k1} & C_{k2} \cdots & C_{kk} \end{bmatrix},$$

the estimates of the regression coefficients are found by:

$$\begin{aligned} b_1 &= C_{11} a_{1y} + C_{12} a_{2y} + \cdots + C_{1k} a_{ky} \\ b_2 &= C_{21} a_{1y} + C_{22} a_{2y} + \cdots + C_{2k} a_{ky} \\ &\vdots \\ b_k &= C_{k1} a_{1y} + C_{k2} a_{2y} + \cdots + C_{kk} a_{ky} \end{aligned}$$

and then

$$d_0 = \bar{Y} - b_1 \bar{X}_1 - b_2 \bar{X}_2 - \cdots - b_k \bar{X}_k .$$

It can be demonstrated[1] that

$$SSE = \sum_{j=1}^{n} (Y_j - \hat{Y}_j)^2 = \sum_{j=1}^{n} \left[Y_j - \bar{Y} - \sum_{i=1}^{k} b_i (X_{ij} - \bar{X}_i) \right]^2$$

$$= \sum_{j=1}^{n} (Y_j - \bar{Y})^2 - \sum_{i=1}^{k} b_i \sum_{j=1}^{n} (X_{ij} - \bar{X}_i)(X_j - \bar{Y}) = \sum_{j=1}^{n} (Y_j - \bar{Y})^2 - \sum_{i=1}^{k} b_i \, a_{iy}$$

which is another way of stating that the corrected total sum of squares for the dependent variable, Y, can be partitioned into a sum of squares attributable to the regression of Y on the X's and a sum of squares not explained by the regression and which is presumably due to the experimental error, i.e.,

$$SST = SSR + SSE .$$

It is, therefore, possible, under the assumptions of (i), (ii), and (iii), to set up the following analysis of variance table to test the hypothesis pertaining to the significance of the overall regression.

1. Anderson, R. L., and Bancroft, T. A., Statistical Theory in Research, McGraw-Hill Book Company, Inc., 1952, p. 171.

ANALYSIS OF VARIANCE TABLE

Source of Variation	d.f.	S.S.	M.S.	F
Regression	k	$\sum_i b_i a_{iy} = SSR$	$\sum_i b_i a_{iy} \big/ (k) = S_R^2$	S_R^2 / S_E^2
Error	$n-k-1$	$\sum_j (Y_j - \hat{Y}_j)^2 = SSE$	$\sum_j (Y_j - \hat{Y}_j)^2 \big/ (n-k-1) = S_E^2$	
Total	n	$\sum_j (Y_j - \bar{Y})^2 = SST$		

The computed F ratio may be compared with the tabular F value for (k) and $(n-k-1)$ degrees of freedom (at the desired level of significance) to test the null hypothesis that all the β_i's $(i=1,2,\cdots,k)$ are equal to zero.

Another useful statistic to be computed is the square of the multiple correlation coefficient,

$$R^2 = SSR / SST,$$

which indicates what proportion of the variation in the Y's, expressed as a sum of squares of deviations from the mean, is explained by the regression of Y on the X's.

Under the assumption of normality, it follows[1] that each of the b_i's $(i=1,2,\cdots,k)$ is normally distributed with mean, β_i, and variance, $C_{ii}\sigma_E^2$, where C_{ii} is the i^{th} diagonal element of the inverse of matrix A. Therefore, to test the null hypothesis that one of the individual regression coefficients is zero, $H_0 : \beta_i = 0$, $(i=1,2,\cdots,k)$, compute

$$t = b_i \Big/ \sqrt{C_{ii} S_E^2}$$

and compare with the tabular t value for $(n-k-1)$ degrees of freedom (at the desired level of significance). To test the null hypothesis that a particular β_i, $(i=1,2,\cdots k)$ is equal to some specified value, $H_0 : \beta_i = \beta$, compute

$$t = (b_i - \beta) \Big/ \sqrt{C_{ii} S_E^2}$$

and again compare with the tabular t value for $(n-k-1)$ degrees of freedom (at the desired level of significance). One other possible test of hypothesis

1. Anderson, R. L., and Bancroft, T. A., Statistical Theory in Research McGraw-Hill Book Company, Inc., 1952, p. 177.

which may be of interest is the null hypothesis that two of the regression coefficients are equal, $H_0: \beta_i = \beta_j (i, j = 1, 2, \cdots, k; i \neq j)$. Testing this hypothesis requires the computation of

$$t = (b_i - b_j) \Big/ \sqrt{(C_{ii} + C_{jj} - 2\, C_{ij})\, S_E^2}$$

to also be compared with the tabular t value for $(n-k-1)$ degrees of freedom (at the desired level of significance).

The β's are known as partial regression coefficients since β_i indicates the amount Y would vary per unit change in X_i if the remaining X's were held fixed and b_i is the sample estimate of this change. It is impossible to determine the relative importance of the various independent variables as they contribute to (or explain) the variation of the dependent variable simply by examination of the magnitudes of the b_i's, since the contribution to the overall regression depends on the product of b_i times X_i. However, the standard partial regression coefficients

$$b_i' = b_i \sqrt{\sum_j (X_{ij} - X_i)^2 \Big/ \sum_j (Y_j - \bar{Y})^2}, (i = 1, 2, \cdots k)$$

offer a proper comparison when ranked in descending order of their absolute values, since they are all expressed in the same units.

The upper and lower confidence bounds for $\beta_i (i = 1, 2, \cdots, k)$ would be computed by

$$b_i \pm t_{(n-k-1)\alpha} \sqrt{C_{ii} S_E^2}$$

and similarly for the difference between two regression coefficients,

$$\beta_i - \beta_j, (i, j = 1, 2, \cdots, k; i \neq j), (b_i - b_j) \pm t_{(n-k-1)\alpha} \sqrt{(C_{ii} + C_{jj} - 2C_{ij}) S_E^2},$$

where $t_{(n-k-1)\alpha}$ is the tabular t value for $(n-k-1)$ degrees of freedom (at the α level of significance).

To place confidence bounds around the average $Y, \hat{Y}_0$, for a specified set of X values, $X_{01}, X_{02}, \cdots, X_{0k}$, the quantities

$$\hat{Y}_0 \pm t_{(n-k-1)\alpha} \sqrt{S_E^2 \left[1/n + \sum_{i,j=1}^{k} \sum C_{ij} (X_{0i} - \bar{X}_i)(X_{0j} - \bar{X}_j) \right]}$$

are computed, where n is the number of observations or data points included in the regression study, $\hat{Y}_0 = d_0 + \sum_{i=1}^{k} b_i X_{0i}$, and the other quantities are defined as above. To compute confidence bounds for an individual predicted

Y value given a specified set of X's, an additional factor of 1 is added within the square brackets of the above expression to give

$$\hat{Y}_0 \pm t_{(n-k-1)\alpha} \sqrt{S_E^2 \left[1 + \frac{1}{n} + \sum_{i,j=1}^{k} \sum c_{ij} (X_{0_i} - \bar{X}_i)(X_{0_j} - \bar{X}_j) \right]}$$

The interpretation concerning the "desired level of significance," α, to be associated with a test of hypothesis or with a confidence interval is the following: If the null hypothesis is rejected at the α level of significance (α is commonly taken to be .05 or .01, but may be any value, depending on the problem at hand and the use which is to be made of the results), this says that a value of the test statistic (computed from the sample data) at least as large as the critical (tabular) value of the test statistic would be expected to occur by chance alone approximately $100 \cdot \alpha$ times out of each 100 repeated samples, assuming the null hypothesis were true. This is, in effect, stating that the null hypothesis would be incorrectly rejected $100 \cdot \alpha$ percent of the time. The same basic idea holds with respect to confidence intervals. An $100 (1 - \alpha)$ per cent confidence interval (computed from the sample data) for a given parameter is interpreted to mean that, if repeated samples were taken and the corresponding confidence intervals computed, approximately $100 (1 - \alpha)$ times out of each 100 repeated samples, the range of the confidence interval would encompass the parameter.

By application of the above computational techniques, it is possible to assess the overall significance of a regression model, rank the independent variables according to their relative contribution to the total regression, test the individual terms in the model for significance, and on these bases determine if the model should be reduced. After a model involving only significant terms has been obtained, confidence intervals for the regression coefficients and predicted Y values may be computed.

D. Computer Program for Multiple Regression Analysis

An IBM 704 FORTRAN II program, identified as TV-MRCA MULTIPLE REGRESSION-COMPREHENSIVE ANALYSIS, was obtained from the SHARE Library in Building 57, Area B, Wright-Patterson Air Force Base, as the most applicable computer program available. Various modifications and additions to this program were deemed necessary.

Modifications were required to render this program compatible with IBM 7090 FORTRAN II and the accompanying procedures in effect at the ASD computer installation in Building 57, Area B, Wright-Patterson Air Force Base.

Originally, this routine provided the least squares fit of a multiple regression model containing a maximum of 23 independent variables for a maximum of 500 observations (data points). It was limited to the consideration of one dependent variable per set of data. The output included the estimates of the regression coefficients and their corresponding standard deviations; the Total, Regression, and Error sums of squares; the averages of all the variables; and predictions and residual errors for each observation used in the study.

Two optional features were also available. A list of synthetic data points (containing no value for the dependent variable) could be added to the input data for which the predicted values and standard deviations of the dependent variable would be computed. Any number or combination of the independent variables could be excluded from the regression model and the analysis rerun on this basis producing the same output, excepting that the computation of the predicted values and residual errors for the observations would be deleted.

The above computer program was rewritten in the form of a subroutine and its capacity increased to provide for the consideration of a regression model containing a maximum of 49 independent variables. Modifications and allowances were made so that the program now contains the following features and supplements to its output.

Since the regression program is now in the form of a subroutine, a main program can be written to read in the input data, perform any desired transformations on the variables, store them on tape, and call the regression routine. Any of the variables could then be designated the dependent variable and a least squares multiple regression analysis be run considering any number (less than 50) or combination of the other variables as dependent variables. Thus, the number of dependent and independent variables per set of data as well as the rerun option has been greatly extended. The output of the program now includes the correlation coefficients between all pairs of the independent variables, the correlation coefficients between each independent variable and the dependent variable, the A matrix (corrected sums of squares and sums of products), the C matrix (the inverse of the A matrix), an Analysis of Variance table, the actual and predicted values of the $\underline{G}$ vector (the corrected sums of products of the X's and the Y), the t tests for testing $H_0: \beta_i = 0, (i = 1, 2, \cdots, k)$, the standard partial regression coefficients, and as before, the averages of the X's and the Y, the estimated regression coefficients and their corresponding standard deviations, and the predicted value and residual error for each observation (data point). Values of the independent variables may be included in the input data for which predicted values of the dependent variable and the corresponding standard deviations will be computed.

APPENDIX II

LITERATURE REVIEW AND DATA PRESENTATION

A. Literature Review

As the statistical development of textile parachute similarity laws was based on the design and performance data of varying sizes of parachutes, all pertinent literature was reviewed to gather the maximum amount of useful information. The review was restricted to the following types of parachutes operating at indicated airspeeds up to 300 knots and altitudes up to 20,000 feet: (1) Circular Flat Solid cloth type parachute canopy, (2) Extended Skirt Solid cloth type parachute canopy, (3) Ringslot type parachute canopy, (4) Ribbon (Flat Circular and Conical) type parachute canopy, and (5) Guide Surface (ribless) type parachute canopy. Furthermore, the collection of data was limited to the dependent variables most indicative of parachute performance—filling time, opening shock, drag coefficient, and stability—and those independent variables considered functionally related to the former. The independent variables chosen are as follows: S_0, l_s/D_0, N_g/D_0, l_r/D_0, S_v/S_0, λ, W/S_0, V, q, Re, M, and Fr.

Only about a third of the more than 150 sources reviewed provided valid and useful information. Many bore deceptive titles since they contained insignificant data. Some had incomplete or unreliable data; for example, one source stated values of 0.4 and 0.5 for the drag coefficient for Extended Skirt parachutes. Others could also not be used since either most of the independent variables were unknown or none of the dependent variables were given. As the stability data in these sources is primarily of an observational nature and a statistical analysis requires definitive experimental information, no useful data of this type could be extracted. All sources had to be considered judiciously. Although similar conditions prevailed in some sources, their data varied appreciably.

Some of the data and terms required modification to suit the purposes of the statistical development. In some cases where atmospheric conditions were not given, reasonable values were assumed to calculate dynamic pressure, Reynolds number, Mach number, etc. The canopy loading definition was changed from gross weight/drag area to gross weight/surface area to provide a term more appropriate to the statistical analysis.

B. Data Presentation

All data are summarized in Tables 6 through 10 for reference; these data may lead to additional evaluations in future studies. These data are pertinent to five types of parachutes operating at indicated airspeeds up to 300 knots and altitudes up to 20,000 feet.

Table 6.a

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
1.558									.188	10.4	.121	.776	.0094	.535		
1.368									.188	11.1	.137	.828	.0100	.571		
1.445									.188	10.8	.130	.805	.0097	.555		
1.036									.326	16.8	.315	1.250	.0151	.864		
1.115									.326	16.2	.293	1.210	.0146	.833		
.934									.326	17.7	.349	1.320	.0154	.910		
1.029									.741	25.4	.719	1.890	.0229	1.310		
.925									.741	26.8	.801	1.990	.0241	1.380		
1.022									.741	25.5	.725	1.900	.0230	1.310		
1.003									1.862	39.8	1.853	2.970	.0359	2.050		
.957							.01	98.0	1.889	41.1	1.976	3.060	.0370	2.110	Free Fall	28
.979			108.50	1.020	1.362				.188	40.6	1.923	3.030	.0366	2.090		
1.136									.188	12.1	.146	.902	.0109	.622		
1.215									.188	11.7	.155	.873	.0105	.566		
1.326									.326	11.2	.142	.835	.0101	.576		
1.249									.326	15.2	.261	1.130	.0137	.781		
1.318									.326	14.8	.248	1.100	.0133	.761		
1.233									.741	15.3	.265	1.140	.0138	.787		
.913									.741	26.8	.812	1.990	.0241	1.380		
.886									.741	27.2	.836	2.030	.0245	1.390		
1.025									1.650	25.3	.723	1.890	.0228	1.300		
.974									1.650	38.5	1.697	2.870	.0347	1.980		
.492									1.650	54.2	3.364	4.040	.0488	2.790		
1.200									.696							
1.200									.696							
1.190									.690	26.5	.580	.473	.0238	2.337		
1.190									.690							
1.170									.679							
1.160									.673							
1.140									.661							
1.150									1.185							
1.150									1.185							
1.140							0		1.174	35.3	1.030	.630	.0316	3.113		
1.140									1.174							
1.130									1.164							
1.110									1.143							
1.070									1.102							
1.090									2.485							
1.080									2.462							
1.080									2.462							
1.070									2.440	52.5	2.280	.938	.0470	4.630		
1.050									2.371							
1.030									2.348							
.990			12.57	1.100	6.00	0		120.0	2.357							
1.160									.766						Infinite Mass	26
1.160									.766							
1.150									.759							
1.140									.752	27.5	.660	.517	.0247	2.422		
1.120									.739							
1.110									.733							
1.070									.706							
1.110									1.199							
1.110									1.199							
1.000							.010		1.080							
1.080									1.166	35.2	1.080	.662	.0316	3.104		
1.070									1.156							
1.040									1.123							
1.020									1.102							
1.040									2.538							
1.040									2.538							
1.030									2.513	52.9	2.440	.993	.0475	4.665		
1.010									2.464							
.990									2.413							
.780									1.903							
.780									1.903							
.780									1.903							
.770							.25		1.879	53.7	2.460	.987	.0482	4.735		
.760									1.854							
.750									1.830							
.740									1.807							

Table 6. b

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_p/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2'' H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
1.110								333.0	13.210	100.0	11.900	2.540	.0900	8.826		
1.120								333.0	19.150	120.0	17.100	3.050	.1070	10.591		
1.280								343.0	5.504	60.0	4.300	1.520	.0540	5.296		
1.170								343.0	13.920	100.0	11.900	2.540	.0900	8.826		
1.100								366.0	4.730	60.0	4.300	1.520	.0540	5.296		
1.050								366.0	12.500	100.0	11.900	2.540	.0900	8.826		14
1.040			12.566	1.000	2.00		0	366.0	17.780	120.0	17.100	3.050	.1070	10.591		
1.100								403.0	4.730	60.0	4.300	1.520	.0540	5.296		
1.060								403.0	12.610	100.0	11.900	2.540	.0900	8.826		
1.040								403.0	17.780	120.0	17.100	3.050	.1070	10.591		
1.150								420.0	4.945	60.0	4.300	1.520	.0540	5.296		
1.070								420.0	12.730	100.0	11.900	2.540	.0900	8.826		
1.070								420.0	18.300	120.0	17.100	3.050	.1070	10.591		
1.070								426.0	4.601	60.0	4.300	1.520	.0540	5.296		
1.020								426.0	12.140	100.0	11.900	2.540	.0900	8.826		
.580			2.640	1.11	8.70		.0113	91.6	14.500	151.0	25.000	1.570	.1320	19.670		
.620			2.600	1.13	8.70		.0115	171.5	15.500	151.0	25.000	1.560	.1320	19.740		
.750			2.410	1.13	9.15		.0083	108.0	3.750	67.5	5.000	.604	.0580	8.980		22
.730			2.410	1.13	9.15		.0083	108.0	18.25	151.0	25.000	1.502	.1320	20.100		
.770			2.410	1.13	9.15		.0083	108.0	46.200	233.8	60.000	2.325	.2040	31.100		
.920									2.190	53.1		.968		4.683		
.910							.09		2.166	53.1	2.380	.968	.0476	4.683		
.880									2.094	53.1		.968		4.683		
.860									2.047	53.1		.968		4.683		
.910									.573							
.910									.573							
.910									.573	27.0	.630	.502	.0242	2.380		
.910									.573							
.900									.567							
.890									.561							
.880									.554							
.870									.957							
.870									.957							
.860									.946						Infinite Mass	
.850						0	.16		.935	35.7	1.100	.663	.0320	3.150		
.850									.935							
.840									.924							
.830									.913							
.840									1.991							
.840									1.991							
.840									1.991							
.830									1.967	52.5	2.370	.675	.0470	4.630		26
.820									1.943							
.810									1.920							
.790			12.57	1.100	6.00			120.0	1.872							
.840									.529							
.850									.536							
.830									.523							
.820									.517	27.3	.630	.502	.2445	2.420		
.810									.510							
.800									.504							
.790							.25		.498							
.820									.918							
.820									.918							
.810									.907							
.800									.896	36.2	1.120	.665	.0325	3.180		
.790									.884							
.780									.874							
.760									.851							
.960							.01		2.342	52.9	2.440	9.95	.0475	4.665		
.940									2.294	52.9	2.440	9.95	.0475	4.665		
1.110									.678							
1.130									.678							
1.120									.672	26.4	.600	.494	.0237	2.328		
1.110									.666							
1.100							.04		.660							
1.070									.642							
1.040									.624							
1.070									1.134	35.0	1.060	6.55	.0314	3.086		
1.070									1.134	35.0	1.060	6.55	.0314	3.086		

Table 6.c

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2 min.)	w/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
1.060									.921	35.0	1.060	.655		3.086		
1.050									.389	35.0	1.060	.655		3.086		
1.020									1.081	35.0	1.060	.655	.0314	3.086		
1.000									1.060	35.0	1.060	.655		3.086		
.920									.375	35.0	1.060	.655		3.086		
.990							.040		.965							
.990									.965							
.980									[illegible]							
.970									.940	[illegible]	[illegible]	.375	.0468	4.594		
.960									.936							
.940									.917							
.920									.847							
1.050									.515							
1.040									.510							
1.030			12.57	1.100	6.0			120.0	.505							26
1.020									.500	26.5	.430	[illegible]	.0262	2.337		
.990									.485							
.960									.470							
.930									.456							
.990									.643							
.990							.090		.635							
.980									.628							
.970									.622	35.0	.641	.648	.0320	3.139		
.960									.615							
.940									.603							
.910									.583						Infinite Mass	
.930									2.213	53.1	2.380	.968		4.683		
.930						0			2.213	53.1	2.380	.968	.0476	4.683		
.920									2.190	53.1	2.380	.968		4.683		
.850			1.450		20.60				10.678	111.7	12.550	.600	.1000	16.897		
.830			1.428		20.70			[illegible]	10.417	111.7	12.550	.600	.1000	16.948		12
.850			1.438		20.60			30	10.667	111.7	12.550	.600	.1000	16.923		
.904			1.450		20.60			10	11.395	111.7	12.550	.600	.1000	16.897		
.989			1.421		20.70			0	12.412	111.7	12.550	.600	.1000	16.974		
1.490								107	6.407	60.0	4.300	1.520	.0540	5.296		
1.430								107	17.017	100.0	11.900	2.540	.0900	8.826		
1.420								107	24.282	120.0	17.100	3.050	.1070	10.591		
1.530				1.000				117	6.573	60.0	4.300	1.520	.0540	5.296		
1.410							0	117	16.775	100.0	11.900	2.540	.0900	8.826		
1.420								117	24.190	120.0	17.100	3.050	.1070	10.591		
1.510								158	6.493	60.0	4.300	1.520	.0540	5.296		
1.380			12.566		2.0			158	16.422	100.0	11.900	2.540	.0900	8.826		
1.350								158	23.085	120.0	17.100	3.050	.1070	10.591		
1.370								228	5.831	60.0	4.300	1.520	.0540	5.296		
1.260								228	[illegible]	100.0	11.900	2.540	.0900	8.826		14
1.240								228	21.206	120.0	17.100	3.050	.1070	10.591		
1.280								243	5.506	60.0	4.300	1.520	.0540	5.296		
1.210								243	[illegible]	100.0	11.900	2.540	.0900	8.826		
1.170								333	5.031	60.0	4.300	1.520	.0540	5.296		
.610			2.640	1.11			0.011	91.6	3.050	67.5	5.000	.670	.0580	8.790		
.725			2.410	1.13			0.008	108	3.620	67.5	5.000	.604	.0580	8.980		
.615			2.600	1.13	8.80		0.012	171.5	3.080	67.5	5.000	[illegible]	.0580	8.830		
.715			2.410	1.13			0.008	108	17.900	151.0	25.000	1.507	.1320	20.100		22
.860			2.640	1.11			0.011	91.6	51.600	233.8	60.000	2.433	.2040	10.200		
.764			2.410	1.13			0.008	108	45.800	233.8	60.000	2.325	.2040	11.100		
.700			2.600	1.13			0.012	171.5	42.000	233.8	60.000	2.410	.2040	10.560		
.941			.614	1.15	9.08			300	.721	42.2	2.117	[illegible]	.0377	7.931		
.709			.442	1.15	11.33			120	1.008	34.3	[illegible]	.1633	.0307	6.983		24
.704			.349	1.15	15.00			120	1.276	38.7	1.819	.1686	[illegible]	8.157		
.724			.196	1.15	16.00		0.00	120	1.667	43.6	2.30	.1383	.0330	10.570		
.828			17,671.5	.90					.503	23.1	.607	21.5200	.0205	.229		
.802			17,671.5	.90	1.111	1.30			.616	26.3	.768	26.1100	.0231	.259		
.587			17,671.5	.90					.699	31.3	1.097	28.6500	.0275	.308		31
.906			17,671.5	.90					.699	25.0	.711	22.9200	.0221	.246	Free Fall	
.838								130.0	.929	31.0	1.103	19.0000	.0285	.557		
.631									.903	34.5	1.407	20.0000	.0310	.606		
.810			7853.98	.950	1.200	[illegible]	[illegible]		.889	31.2	1.091	[illegible]	.0281	.550		13
.881									.866	30.0	1.003	16.176	.0270	.529		
.650									.968	35.3	1.337	[illegible]	.0318	.622		
.690									.888	35.5	1.406	21.2500	.0311	.629		

Table 6.d

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2'' H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
0.850			7853.98	.950	1.20		.005	130.0	.421	20.7	.496	12.910	.0189	.365	Free Fall	13
0.737									.389	21.4	.529	13.340	.0192	.377		
0.923									.478	21.5	.518	13.080	.0194	.379		
0.816									[illegible]	21.0	.508	13.070	.0189	.370		
0.961										19.4	.431	12.030	.0174	.342		
0.710										22.6	.584	14.030	.0203	.398		
1.190										17.7	.348	10.950	.0159	.312		
0.970										19.3	.427	11.970	.0173	.340		
1.140										17.8	.364	11.050	.0160	.314		
0.752									.661	27.8	.879	17.112	.0250	.490		
0.899			3216.99	1.810	1.00		.003	125.0	.478	21.4	.532	8.574	.0192	.472		
0.974									.653	24.0	.671	9.623	.0215	.529		
1.080									.503	20.0	.464	8.007	.0179	.441		
1.090									.503	20.0	.463	7.997	.0179	.441		
0.675									.653	28.9	.967	11.550	.0259	.637		
0.626									.684	31.0	1.093	12.220	.0279	.683		
0.405									.932	45.0	2.303	17.730	.0405	.992		
0.488									.932	41.0	1.912	16.160	.0369	.904		
0.433									.935	43.5	2.152	17.140	.0391	.959		
-0.651									.708	30.9	1.068	12.190	.0278	.681		
0.706			7853.98	.950	1.20		.005	130.0	.906	34.1	1.284	20.510	.0308	.601		
0.780									.887	32.1	1.138	19.300	.0290	.566		
0.756									.887	32.6	1.174	19.600	.0294	.574		
0.683									.887	34.3	1.299	20.630	.0309	.605		
0.730									.883	33.2	1.217	19.960	.0300	.585		
0.692										34.1	1.284	20.510	.0308	.601		
0.811										31.5	1.096	18.940	.0284	.555		
0.594										36.8	1.496	22.130	.0332	.648		
0.794										31.7	1.118	19.170	.0286	.559		
0.795										31.8	1.117	19.120	.0287	.560		
0.836			615.0	.750	1.00		.000	100.0	.350	19.2	.418	3.330	.0172	.650		29
1.200										17.6	.342	3.050	.0158	.596		
0.680										21.6	.515	3.740	.0194	.731		
0.896										18.8	.390	3.260	.0169	.637		
0.507										25.0	.690	4.340	.0224	.847		
1.200										16.2	.290	2.810	.0145	.550		
0.522										24.6	.670	4.260	.0221	.834		
0.790										20.0	.442	3.470	.0180	.677		
0.660										19.5	.530	3.380	.0175	.660		
0.697				.816			.003	120.0	.344	20.3	.494	3.610	.0223	.677		2
0.948										17.4	.363	3.090	.0191	.580		
0.837										18.5	.411	3.290	.0202	.616		
0.754										19.5	.456	3.460	.0214	.650		
0.748										20.0	.460	3.560	.0224	.667		
0.743										20.1	.463	3.570	.0242	.668		
0.595										22.4	.579	3.980	.0250	.756		
0.664										20.8	.518	3.700	.0225	.694		
0.724										19.9	.475	3.540	.0215	.664		
		1400.0	706.0	.850		000.0	.003	110.0	.230	175.0	36.35	33.300	.1570	5.620		20
		1500.0								175.0	36.35	33.100	.1570	5.620		
		1800.0								219.0	54.90	41.700	.1960	7.050		
		1650.0								219.0	54.90	41.700	.1960	7.050		
		3000.0								256.0	77.70	48.700	.2290	8.240		
		2200.0								294.0	102.60	56.000	.2630	9.450		
		1050.0	804.0	.845			.002		.256	175.0	36.35	35.600	.1570	5.450		
		1000.0								175.0	36.35	35.600	.1570	5.450		
		1900.0								219.0	54.30	44.500	.1960	6.830		
		1700.0								219.0	54.90	44.500	.1960	6.830		
		2100.0								256.0	77.70	52.000	.2290	7.990		
		3300.0								294.0	102.60	59.700	.2630	9.170		
		3000.0								256.0	77.70	52.000	.2230	7.990		
	.69	3590.0	615.8	.815			.000	110.0	.947	373.9	134.50	56.030	.3368	12.460		7
	.58	3975.0								373.9	134.90	56.030	.3193	12.460		
	.94	2900.0								373.0	125.80	56.030	.3321	12.460		
	.70	5850.0								373.0	125.80	56.030	.3321	12.460		
	.83	2350.0								373.3	125.80	56.030	.3321	12.460		
		3000.0								400.1	147.10	59.460	.3591	13.330		
	.65	3375.0								407.6	166.10	61.080	.3659	13.580		
	.64	3350.0								411.[illegible]	156.90	61.120	.3709	13.780		
	.75	1850.0								137.7	27.70	25.770	.1787	6.590		

Table 6. e

Summary of Data - Circular Flat Parachute

C_D	t_r (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_v/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta p = 1/2"H_2O$ ($ft^3/ft^2 min.$)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
	.52	2640.0								199.7	28.30	25.03	.1806	6.650		
	.58	2325.0								201.9	29.50	25.30	.1809	6.730		
		2040.0								201.9	29.50	25.30	.1844	6.730		
		4500.0								201.9	29.50	25.30	.1844	6.730		
		2400.0								208.1	31.30	26.08	.1900	6.930		
		2250.0								208.1	31.30	26.08	.1900	6.930		
		1860.0								208.1	31.30	26.08	.1900	6.930		
		3600.0								239.5	41.60	30.01	.2149	7.980		
		2000.0								239.5	41.60	30.01	.2149	7.980		
		4100.0								241.6	42.30	30.27	.2206	8.050		
		2750.0								241.6	42.30	30.27	.2206	8.050		
		2140.0								241.6	42.30	30.27	.2206	8.050		
		3700.0								243.7	43.00	30.54	.2226	8.120		
		1825.0								243.7	43.00	30.54	.2226	8.120		
		4240.0								243.7	43.00	30.54	.2226	8.120		
		3975.0								302.4	67.20	37.89	.2782	10.080		
		2640.0								304.5	68.80	38.15	.2814	10.150		
	.59	3525.0								304.5	68.80	38.15	.2814	10.150		
	.82	3000.0								304.5	68.80	38.15	.2814	10.150		
	.95	2150.0								304.5	68.80	38.15	.2814	10.150		
		3450.0								306.7	69.10	38.43	.2822	10.220		
		5250.0								306.7	69.10	38.43	.2822	10.220		
		3210.0								308.6	72.40	38.67	.2852	10.280		
	.73	2425.0						130.0	.347	308.6	72.40	38.67	.2887	10.280		
	.50	4000.0								308.6	72.40	38.67	.2887	10.280		
	.63	4100.0								308.6	72.40	38.67	.2887	10.280		
	.77	4160.0								374.4	96.40	46.92	.3454	12.470		
	.76	4570.0								374.4	96.40	46.92	.3454	12.470		
	.76	4700.0								374.4	96.40	46.92	.3454	12.470		
	.70	2650.0								226.5	30.73	24.17	.2127	7.547		
	.20	3400.0								226.5	30.73	24.17	.2127	7.547		
	.52	2640.0								227.5	31.00	24.28	.2136	7.580		
	.52	2700.0								227.5	31.00	24.28	.2136	7.580		
	.40	3270.0	615.8	.815	1.00	000.0	.000			229.9	31.66	24.54	.2159	7.660		
		3750.0								241.4	35.08	25.76	.2267	8.043		
		3260.0								243.7	35.80	26.01	.2295	8.120		
		3650.0								246.1	36.50	26.26	.2317	8.200		
		2865.0								249.8	37.60	26.26	.2352	8.323		
		4725.0								300.2	54.39	32.04	.2829	10.002		
	.57	4000.0								302.5	55.22	32.29	.2851	10.080	Free Fall	7
	.47	4150.0								302.5	55.22	32.29	.2851	10.080		
	.45	4250.0								307.1	[illegible]	32.78	.2894	10.240		
	.41	5700.0								365.9	99.27	39.05	.3382	12.190		
	.54	5250.0								365.9	99.27	39.05	.3382	12.190		
	.53	4700.0								365.9	99.27	39.05	.3382	12.190		
	.94									365.9	99.27	39.05	[illegible]	12.190		
	.94	1850.0								373.9	125.8	56.03	.3321	12.460		
	.74	2950.0								363.9	96.40	45.60	.3332	12.120		
		4050.0								370.2	99.80	46.39	.3390	12.330		
	1.18	3500.0								384.9	111.9	48.22	.3590	12.820		
	2.50	4600.0								407.7	120.6	51.12	.3779	13.590		
	.52	3300.0								232.2	33.50	24.78	.2220	7.737		
	.49	2675.0								232.2	33.50	24.78	.2220	7.737		
	.62	3160.0								234.5	34.10	25.03	.2242	7.813		
	.41	4000.0								251.6	38.50	26.85	.2380	8.383		
	.43	3575.0								251.6	38.50	26.85	.2380	8.383		
	.25	3815.0						[illegible]	[illegible]	251.6	38.50	26.85	.2380	8.383		
	.53	3325.0								263.6	42.10	28.13	.2494	8.783		
	.59	3390.0								267.8	[illegible]	28.58	.2531	8.923		
	.36	4650.0								297.3	42.80	31.79	.2795	9.926		
	.32	[illegible]								297.3	42.80	31.73	.2795	9.926		
	.42	4025.0								297.3	[illegible]	31.73	.2795	9.926		
	.38	4750.0								308.8	80.70	[illegible]	.2916	10.290		
		4740.0								368.2	80.70	39.30	.3444	12.270		
		[illegible]								368.2	80.70	39.30	.3444	12.270		
	.45	5050.0								368.2	80.70	39.30	.3444	12.270		
	.42	6160.0								368.2	80.60	39.30	.3444	12.270		
	.72	3675.0							[illegible]	188.5	[illegible]	27.64	.1638	6.167		
	.44	2430.0						[illegible]	[illegible]	188.5	[illegible]	27.64	.1638	6.167		
	.66	3650.0							[illegible]	188.5	[illegible]	27.64	.1638	6.167		

Table 6.f

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2 min)	W/S_o (psf)	V (ft/sec)	q (psf)	Re × 10^{-5}	M	Fr	Type of Test	Ref.
		1420.0								186.4	33.??	27,330	.1691	6.211		
	.75									186.4	35.6?	27,930?	.1691	6.211		
	.76	2150.0								188.3	[illegible]	28,220	.1669	6.274		
	.70	1300.0							.347	188.3	[illegible]	28,220	.1669	6.274		
	1.12	1800.0								188.3	[illegible]	28,220	.1669	6.274		
	.66	2950.0								242.6	53.80	36,350	.2155	8.083		
	.67	2240.0								244.5	[illegible]	36,640	.2171	8.146		
	.92	1810.0						130.0		248.3	70.0?	37,200	.2205	8.273		
	.83	2175.0								289.5	83.10?	43,380	.2580	9.646		
	.90	2780.0								302.6	83.10	45,340	.2697	10.080		
	.81	3600.0								302.6	83.10	45,340	.2697	10.080		
	.59	2800.0								308.3	82.70?	46,200	.2798	10.270		
	.55	4150.0							.347	355.1	119.??	53,210	.3182	11.830		
	.75	2150.0								370.1	130.30	55,460	.3316	12.330		
	.58	3050.0								370.1	130.30	55,460	.3316	12.330		
	.60	3210.0								372.0	127.10	55,740	.3339	12.390		
	.73	3925.0								373.9	134.50	56,030	.3371	12.460		
	.48	3775.0								372.0	129.50	55,740	.3304	12.390		
		5500.0								373.9	128.50	56,026	.3356	12.460		
		3900.0								400.1	[illegible]	59,950	.3482?	13.330		
		2375.0								402.0	142.50	60,240	.3511	13.390		
		6800.0								402.0	142.50	60,234	.3511	13.390		
		3950.0								403.9	152.00	60,520	.3681	13.450		
		4000.0								403.9	152.00	60,520	.3681	13.450		
	.69	4900.0								403.9	143.80	60,520	.3549	13.450		
		4000.0								456.4	181.20	68,330	.4086	15.210		
	.57	4300.0	615.8?	.815?						463.1	189.60	69,330	.4176	15.430		
	1.20	2150.0								463.1	189.60	69,330	.4176	15.430		
	.90	4450.0?								467.6	204.40	70,070	.4216	15.580		
	.61	2825.0								204.3?	31.72	25,550?	.1913	6.796		
		1600.0								203.3?	31.72	25,550	.1913	6.796		
	.57	2?50.0								[illegible]	31.72	[illegible]	.1913	6.796		
	.48	2425.0								206.0?	32.38	25,810?	.1932	6.864		
	.83	2140.0								208.1	32.74	26,080	.1941	6.934	Free Fall	7
	.63	2450.0			1.00	[illegible]				208.1	32.74	26,080	.1941	6.934		
	.89	2375.0					.030?	100.0?	[illegible]	208.1	32.74	26,080	.1941	6.934		
	.91	2050.0								208.1?	32.74	26,089	.1941	6.934		
	.51	2260.0								[illegible]	33.32	26,320	.1959	6.997		
	.27	3150.0?								[illegible]	34.05	26,600	.1980	7.074		
	.83	1750.0?								214.9	[illegible]	26,870	.2011	7.144		
	.63	2725.0								[illegible]	47.?	[illegible]	.2254?	8.190		
	.50	3020.0								[illegible]	47	[illegible]	.2337?	8.329		
		3330.0?								[illegible]	[illegible]	31,330?	[illegible]	8.329		
	.44	3010.0								250.?	47.22	31,330	.2332	8.329		
		1890.0?								[illegible]	47.22	31,330	.2332	8.329		
	.74	27?0.0								250.0	47.22	31,330	.2332	8.329		
	.55	3200.0								250.0	46.84?	31,330	.2302?	8.329		
	.71	2350.0?								250.0	46.84	31,330	.2302	8.329		
		1500.0?								254.2	48.81?	31,870	.2371	8.470		
	.51	3330.0								281.4	57.61?	35,260	.2572?	9.376		
	.48	4100.0?								302.4	66.98?	37,890	.2704	10.080		
	.54	4340.0?								302.4	[illegible]	37,890	.2704	10.080		
	.62	3675.0								312.8	[illegible]	39,200	[illegible]	10.420		
	.67	3700.0								[illegible]	90.00?	44,810	[illegible]	11.910		
	.83	3200.0								[illegible]	[illegible]	44,810	[illegible]	11.910		
	.61	4945.0?								[illegible]	[illegible]	45,600	[illegible]	12.120		
	.77	3800.0								[illegible]	[illegible]	45,600	[illegible]	12.120		
	.49	3000.0								[illegible]	[illegible]	[illegible]	.2093?	7.269		
	.51	2275.0?								[illegible]	[illegible]	26,180	.2067?	7.340		
	.30	4300.0?								[illegible]	[illegible]	26,180	[illegible]	7.340		
		3000.0								[illegible]	[illegible]	26,180	.2077	7.340		
	.52	3?50.0								[illegible]	[illegible]	[illegible]	[illegible]	8.398?		
	.40								[illegible]	[illegible]	[illegible]	[illegible]	.2142	8.398		
	.44	4000.0?	[illegible]	[illegible]				[illegible]		[illegible]	[illegible]	29,800?	.2142	8.398		
		3950.0?								233.3	[illegible]	29,800?	.2142	8.398		
		4360.0								249.8	44.90	31,260?	.2263	8.848		
		5270.0?								303.2?	[illegible]	38,050?	.2742	10.810		
		[illegible]								[illegible]	[illegible]	38,050	.2742	10.810		
		[illegible]								[illegible]	[illegible]	38,830	.2742	10.830		
		[illegible]								[illegible]	[illegible]	38,830	.2742	10.830		

Table 6. g

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
		4900.0	452.0	.710	1.00	000.0	.000	130.0	.466	306.7	68.1	[illegible]	.2801	10.040	Free Fall	7
	.74		452.4	.701						188.3	33.7	24.180	.1687	6.780		
	.75		452.4	.701						188.3	33.7	24.180	.1687	6.780		
		4300.0	452.0	.730						226.5	30.7	29.080	.2115	8.153		
		4475.0								226.5	30.7	29.080	.2115	8.153		
	.17	6650.0								226.5	30.7	29.080	.2115	8.153		
	.58	4100.0								236.8	34.0	30.410	.2236	8.524		
		4050.0								236.8	33.6	30.410	.2223	8.524		
		4700.0								250.7	38.1	32.190	.2367	9.024		
	.31	4370.0								250.7	37.6	32.190	.2364	9.024		
	.45	1475.0								251.6	37.9	32.300	.2362	9.057		
	.84	1575.0	615.8	.815					.343	190.1	35.2	28.470	.1725	6.334		
	.78	1700.0								190.1	35.2	28.470	.1725	6.334		
	.67	1900.0								192.3	36.1	28.800	.1745	6.407		
	.73	1580.0								192.3	36.1	28.800	.1745	6.407		
	.67	1980.0								195.7	37.3	29.320	.1776	6.521		
	.44	3025.0								246.4	57.9	36.910	.2212	8.210		
	1.19	2800.0								246.4	57.9	36.910	.2212	8.210		
	.62	3175.0								246.4	57.9	36.910	.2212	8.210		
		2380.0								246.4	57.9	36.910	.2212	8.210		
	.50	3700.0								302.6	87.1	45.330	.2711	10.080		
	.51	3690.0								304.5	88.2	45.610	.2728	10.150		
	.62	3390.0								304.5	88.2	45.610	.2728	10.150		
	.57	3550.0								308.3	90.4	46.180	.2763	10.270		
	.60	3620.0								313.9	93.7	47.027	.2813	10.460		
	.	2375.0								366.4	127.7	54.890	.3283	12.210		
	.48	3575.0								368.3	122.1	55.170	.3271	12.270		
	.84		452.0	.701					.466	190.1	34.4	24.410	.1703	6.840		
	.89										34.4		.1703			
	.89										33.9		.1693			
											33.9		.1693			
		1425.0									35.2		.1725			
		1500.0									35.2		.1725			
		1400.0									35.2		.1725			
		1475.0									35.2		.1725			
		1550.0									35.2		.1725			
	.65	2500.0								246.4	57.7	31.640	.2208	9.520		
		2425.0								246.4	57.7	31.640	.2208	9.520		
		1950.0								246.4	57.7	31.640	.2208	9.520		
		1650.0								246.4	57.7	31.640	.2208	9.520		
		2450.0								246.4	57.7	31.640	.2208	9.520		
										250.1	59.7	32.110	.2245	9.000		
	.67									250.1	59.7	32.110	.2245	9.000		
	.56									250.1	59.7	32.110	.2245	9.000		
	.39									250.1	59.7	32.110	.2245	9.000		
	.63									250.1	59.7	32.110	.2245	9.000		
		2000.0								302.6	84.0	38.850	.2683	10.900		
	.69	6200.0								302.6	84.0	38.850	.2683	10.900		
		3200.0								304.5	88.2	39.100	.2700	11.000		
		2875.0								304.5	88.2	39.100	.2700	11.000		
		3250.0								304.5	88.2	39.100	.2700	11.000		
		2775.0								304.5	88.2	39.100	.2700	11.000		
	.68	2650.0								306.4	87.4	39.340	.2728	11.000		
										312.0	93.6	40.060	.2813	11.200		
	.67									312.0	93.6	40.060	.2813	11.200		
	.50									312.0	93.6	40.060	.2813	11.200		
										366.4	125.5	47.040	.3319	13.200		
	.59									366.4	125.5	47.040	.3319	13.200		
	.60	4325.0								370.1	130.3	47.520	.3316	13.300		
	.62	2750.0								370.1	130.3	47.520	.3316	13.300		
		4150.0								370.1	130.3	47.520	.3316	13.300		
		3625.0								370.1	130.3	47.520	.3316	13.300		
	.64									373.9	130.7	48.010	.3387	13.500		
	.51									373.9	130.7	48.010	.3387	13.500		
	.55									373.9	130.7	48.010	.3387	13.500		
	.77	3200.0								402.0	153.7	51.620	.3602	14.470		
	.73	5050.0								407.6	152.0	52.340	.3591	14.670		
	.98	4350.0								407.6	152.0	52.340	.3591	14.670		
	.77	4750.0								407.6	152.0	52.340	.3591	14.670		
	.93	4900.0								407.6	152.0	52.340	.3591	14.670		

Table 6. h

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_p/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P \cdot 1/2"H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
		3750.0								206.0	32.4	22.12	.1932	7.420		
	.36	6350.0								206.0	32.4	22.12	.1932	7.420		
		2475.0								206.0	32.4	22.12	.1932	7.420		
		3075.0								206.0	32.4	22.12	.1932	7.420		
	.54	2725.0								206.0	31.2	22.12	.1897	7.420		
	.51	2200.0								208.1	31.8	22.35	.1916	7.490		
	.56									208.1	31.8	22.35	.1916	7.490		
	.76	3925.0								212.3	34.4	22.80	.1992	7.640		
	.67	2600.0								214.4	33.8	23.03	.2011	7.720		
	.53	2425.0								250.0	45.9	26.85	.2302	8.999		
		4400.0								250.0	45.9	26.85	.2302	8.999		
	.60	2750.0								250.0	45.9	26.85	.2302	8.999		
	.59	3200.0								250.0	45.9	26.85	.2302	8.999		
	.62	3450.0								287.7	61.4	30.898	.2659	10.360		
	.69	3350.0								298.2	65.9	32.027	.2756	10.730		
	.55	3550.0								298.2	65.9	32.027	.2756	10.730		
	.75	3780.0								300.2	65.2	33.220	.2723	10.810		
	.98	2350.0								300.2	65.2	33.220	.2723	10.810		
	.58	4600.0								300.2	65.2	33.220	.2723	10.810		
		3550.0								304.5	68.8	32.700	.2814	10.960		
	.65	4000.0								306.7	69.7	32.920	.2835	11.040		
		4750.0								376.5	108.2	40.440	.3532	13.550		
	.63	6250.0								376.5	108.2	40.440	.3532	13.550		
	.59	5200.0								376.5	108.2	40.440	.3532	13.550		
	.68	4600.0								376.5	108.2	40.440	.3532	13.550		
	.76	5125.0								394.7	112.9	42.390	.3608	14.210		
	.77	5350.0								395.7	112.9	42.390	.3608	14.210		
		3000.0								226.5	30.7	20.720	.2129	8.150		
		3150.0								227.5	31.0	20.810	.2138	8.189		
		3250.0								227.5	31.0	20.810	.2138	8.189		
		2775.0								227.5	31.0	20.810	.2138	8.189		
	.88	2050.0								229.9	30.9	21.030	.2134	8.276		
	.72	1650.0	452.0	.701	1.0	0	0	130	.600	229.9	30.9	21.030	.2134	8.276	Free Fall	7
		4700.0								258.6	39.2	23.660	.2426	9.309		
		2800.0								258.6	39.2	23.650	.2426	9.309		
		5050.0								258.6	39.2	23.660	.3387	13.500		
		3050.0								258.6	39.2	23.660	.3387	13.500		
		3000.0								258.6	39.2	23.660	.3387	13.500		
		4900.0								304.8	54.4	27.880	.2830	10.970		
	.62	4300.0								304.8	54.4	27.880	.2830	10.970		
		5450.0								307.1	55.7	28.090	.2881	11.050		
		3600.0								307.1	55.7	28.090	.2881	11.050		
	.34	3750.0								307.1	55.7	28.090	.2881	11.050		
	.60	4375.0								372.8	83.0	34.100	.3497	13.420		
	.20	5400.0								372.8	83.0	34.100	.3497	13.420		
	.34	5700.0								372.8	83.0	34.100	.3497	13.420		
	.38	4750.0								386.7	89.3	35.380	.3690	13.920		
	.44	5125.0								386.7	89.3	35.380	.3690	13.920		
	.54	3650.0								389.0	93.2	35.590	.3712	14.000		
	.37	6500.0								389.9	93.6	35.670	.3720	14.000		
	.31	5850.0								392.3	94.8	35.890	.3743	14.120		
	.64	1800.0								182.6	30.0	23.450	.1622	6.573		
	.47	1950.0								182.6	30.0	23.450	.1622	6.573		
	.52	2810.0								182.6	30.0	23.450	.1622	6.573		
	.59	2410.0								182.6	30.0	23.450	.1622	6.573		
	.54	2640.0								186.4	33.9	23.330	.1691	6.709		
	.62	3325.0								244.5	53.8	31.330	.2171	8.801		
	.61	3760.0								244.5	54.8	31.390	.2171	8.801		
		4120.0								244.5	53.8	31.390	.2171	8.801		
	.46	4050.0								246.4	54.6	31.640	.2188	8.870		
	.55	4010.0								252.0	57.2	32.360	.2238	9.071		
	.40	6100.0								298.9	81.0	38.380	.2666	10.760		
	.53	4575.0								298.9	81.0	38.380	.2666	10.760		
	.53	4150.0								298.9	81.0	38.380	.2666	10.760		
	.62	4550.0								300.7	82.1	38.610	.2682	10.820		
	.55	4400.0								300.7	82.1	38.610	.2682	10.820		
		6500.0								358.3	115.9	46.080	.3184	12.920		
		6750.0								366.4	120.6	47.060	.3254	13.190		
		6775.0								366.9	120.6	47.090	.3248	13.190		
		6800.0								368.1	121.7	47.290	.3265	13.260		

Table 6.i

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	[illegible]	at $\Delta P = 1/2''$ H_2O (ft^3/ft^2 min.)	W/S (psf)	V (ft/sec)	q (psf)	Re [illegible]	[illegible]	Fr	Type of Test	Ref.
		5600.0		.701			.000	130.0	.966	968.3	[illegible]	67,2??	.126?	13.260		
	1.51	6960.0		.701			.000	130.0	.966	373.?	130.3?	98,01?	.3331	13.960		7
		1000.0														
	1.30	1300.0						120.0								
		1050.0														
	1.28	1560.0														
	1.29	1625.0														
		1225.0						140.0								
		800.0						60.0								
		1950.0														
	.75	1530.0						100.0								
		750.0														
		1500.0														
	1.11	1300.0						120.0		168.9	33.11	2?.?10	.1516	6.074		
		1070.0														
		1200.0						130.0								
		1125.0						180.0								
	1.18	1075.0						200.0								
	1.15	860.0						220.0								
	1.05	680.0						220.0								
	1.30	800.0						240.0								
	1.15	1200.0						200.0								
	1.18	1075.0						200.0								
	1.15	860.0						220.0								
	1.05	680.0						220.0								
	1.30	800.0						240.0								
		1520.0						60.0								
	.73	2080.0						80.0								
	.90	1675.0						100.0								
		1650.0						100.0								
	.76	1800.0														
	1.06	1700.0														
	1.03	1810.0						120.0				31.76				
	1.01	1630.0														
	.75	1800.0														
	.80	1830.0	452.?	.700	1.0	0.0	.01	140.0	.90?						Free Fall	8
	.80	2610.0						140.0								
	.90	1420.0						160.0		211.?	?1.7?		.1092	7.?93		
	1.06	1570.0														
	.88	1995.0						180.0								
	.80	2320.0														
	1.25	1910.0														
	1.13	1300.0														
	.88	1275.0						200.0								
	1.22	[illegible]														
	1.16	[illegible]										31.76				
	1.67	[illegible]						220.0								
	2.?8	[illegible]						220.0								
	1.07	[illegible]						260.0								
	1.15	76?.0						260.0								
	1.09	[illegible]						260.0								
	.75	2?00.0						60.0	.9??							
	.82	2110.0						80.0								
	.80	2320.0						100.0								
	.70	?980.0						100.0								
	.90	2225.0														
	.71	2270.0														
	1.04	1000.0						120.0								
	.87	1700.0														
	.78	37??.0														
	.9?	1750.0														
	.70	[illegible]						140.0								
	.81	2570.0						160.0	.90?	25?.0	71.88	81.0??	.226?	9.104		
	.89	18?0.0						160.0								
	.73	2120.0														
	.87	1680.0														
	.70	[illegible]						180.0								
	[illegible]	1?5?.0														
	1.1?	[illegible]						200.0								
	1.1?	[illegible]						200.0								

Table 6.j

Summary of Data - Circular Flat Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-5}	M	Fr	Type of Test	Ref.
	.83	1480.0						200.0								
	1.04	1410.0						200.0								
	.95	1620.0						220.0		253.0	73.8	38.09	.2269	9.104		
	1.30	1340.0						220.0								
	1.09	1140.0						240.0								
	1.15	1200.0						240.0								
	1.13	1240.0						260.0								
	.65	3430.0						60.0								
	.61	3780.0						80.0								
	.70	3300.0						100.0								
	.75	2770.0						120.0								
		3945.0						120.0								
	.67	3840.0						120.0								
	.63	2820.0						120.0								
	.70	3300.0						120.0								
	.83	2215.0						120.0								
	.65	7350.0						140.0								
	.65	3070.0						140.0								
	.63	3220.0						140.0		295.0	101.12	44.41	.2646	10.62		
	.69	2530.0						160.0								
	.97	1675.0						160.0								
	.68	2910.0						180.0								
	.6[illegible]	3200.0						180.0								
	.6[illegible]	3080.0						180.0								
	.6[illegible]	7490.0						200.0								
	.78	2150.0						200.0								
	1.04	1560.0						200.0								
	1.70	2020.0						200.0								
	.9[illegible]	1645.0						220.0								
	1.13	2900.0	452.0	.701	1.0	0	.01	240.0	.498						Free Fall	11
	1.3[illegible]	1050.0						240.0								
	1.00	1260.0						260.0								
	1.[illegible]	960.0						260.0								
	.61	4970.0						60.0								
	.85	2940.0						100.0								
	.94	2400.0						120.0								
	1.1[illegible]	1640.0						120.0								
	.69	3845.0						140.0								
	.[illegible]	6410.0						140.0								
	.86	1870.0						160.0		[illegible]	132.75	50.89	.3031	12.16		
	.96	1680.0						160.0								
	.6[illegible]	3300.0						180.0								
	.6[illegible]	3500.0						180.0								
	.7[illegible]	3275.0						180.0								
	1.47	950.0						200.0								
	1.06	1515.0						220.0								
	1.36	1500.0						240.0								
	1.0[illegible]	1320.0						260.0								
	1.07	1910.0						260.0								
	.[illegible]	4600.0						100.0								
	.68	3760.0						100.0								
	.81	3340.0						120.0								
	.76	4675.0						120.0								
	.[illegible]	1225.0						140.0								
	.56	4710.0						140.0								
	.8[illegible]	[illegible]						200.0		180.0	167.7[illegible]	57.212	.3408	13.67		
	.65	[illegible]						200.0								
	1.21	[illegible]						200.0								
	.81	[illegible]						[illegible]								
	.7[illegible]	[illegible]						220.0								
	1.1[illegible]	[illegible]						220.0								
	[illegible]	[illegible]						[illegible]								
	[illegible]	[illegible]						[illegible]								

Table 7. a

Summary of Data - Extended Skirt (10%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	W_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P=1/2"H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
10% Extension																
.797			1.910	1.000	17.96		0	120.0	10.000	111.7	12.550	.600	.1000	15.775	Infinite Mass	12
.822			2.120		17.04		0	10.0	10.320	111.7	12.550	.600	.1000	15.363		
.824			2.012		17.49		0	275.0	10.330	111.7	12.550	.600	.1000	15.556		
.810			2.021		17.45		0	30.0	3.390	111.7	4.180	.600	.1000	15.556		
.838			111.10	.600	1.345	0	.01	91.0	.139	12.1	.165	.913	.0109	.618	Free Fall	28
.910							.01		.139	11.6	.152	.875	.0104	.593		
.838									.139	12.1	.165	.913	.0109	.618		
.828									.274	17.1	.330	.129	.0154	.874		
.809									.274	17.3	.338	1.305	.0155	.884		
.731									.274	18.2	.374	1.373	.0163	.930		
.582									.679	32.1	1.164	2.422	.0288	1.640		
.590									.679	31.9	1.150	2.407	.0286	1.630		
.532									.679	33.6	1.276	2.535	.0302	1.717		
.979			111.10	1.400					.184	12.8	.187	.966	.0115	.654		
.979									.184	12.8	.187	.966	.0115	.654		
.934									.184	13.1	.196	.989	.0118	.669		
.889									.274	16.4	.308	1.238	.0148	.838		
.900									.274	16.3	.304	1.229	.0147	.833		
.911									.274	16.2	.300	1.222	.0146	.823		
.885									.679	25.9	.768	1.954	.0233	1.323		
.864									.679	26.2	.786	1.977	.0236	1.338		
.864									.679	26.2	.786	1.977	.0236	1.338		
.848									1.800	42.8	2.125	3.229	.0386	2.187		
.962									1.665	38.9	1.733	2.935	.0350	1.988		
.928									1.665	39.6	1.796	2.988	.0357	2.024		
.878									.184	13.5	.210	1.019	.0122	.690		
.890									.184	13.4	.206	1.011	.0121	.685		
.842									.184	13.8	.216	1.041	.0124	.705		
1.016									.274	15.3	.269	1.154	.0138	.782		
.845									.274	16.8	.325	1.268	.0151	.858		
1.016									.274	15.3	.269	1.154	.0138	.782		
.880									.679	25.9	.771	1.954	.0233	1.323		
.763									.679	27.8	.889	2.098	.0250	1.421		
.810									.679	27.0	.838	2.037	.0243	1.380		
1.172				1.240					.139	10.2	.118	.770	.0091	.521		
1.087									.139	10.6	.128	.800	.0095	.542		
1.087									.139	10.6	.128	.800	.0095	.542		
.896									.274	16.4	.126	1.238	.0146	.838		
.807									.274	17.3	.340	1.305	.0154	.884		
.896									.274	16.4	.305	1.238	.0146	.838		
.912									.679	[illegible]	.744	1.932	.0228	1.308		
.898									.679	25.8	.756	1.947	.0230	1.318		
.920									.679	25.5	.738	1.924	.0228	1.303		
.751									1.508	40.9	1.874	3.086	.0368	2.090		
.729									1.508	41.5	1.929	3.132	.0370	2.120		
.903									1.845	41.8	2.044	3.154	.0376	2.136		
1.210									.139	10.0	.114	.755	.0093	.511		
1.185									.139	10.1	.117	.762	.0091	.516		
1.077									.139	10.6	.126	.800	.0095	.542		
.837									.274	16.9	.327	1.275	.0152	.864		
1.062									.274	15.0	.258	1.132	.0135	.766		
.827									.274	17.0	.331	1.283	.0153	.869		
.831									.679	26.7	.816	2.015	.0241	1.364		
.877			111.10						.679	26.0	.774	1.962	.0234	1.329		
.850									.679	26.4	.798	1.992	.0238	1.349		
1.130				1.080					.139	10.3	.122	.777	.0092	.526		
1.088									.139	10.5	.127	.792	.0094	.536		
1.249									.139	9.8	.111	.740	.0088	.501		
.860									.274	16.6	.318	1.252	.0148	.848		
.986									.274	15.5	.277	1.170	.0139	.792		
.870									.274	16.5	.314	1.245	.0148	.843		
.883									.679	25.8	.769	1.947	.0231	1.318		
.843									.679	26.4	.854	1.992	.0236	1.349		
.794									.679	27.2	.331	2.052	.0244	1.390		
.536									1.508	52.7	2.410	3.977	.0471	2.693		
.728									1.508	45.0	2.000	3.396	.0401	2.300		
.863									1.845	41.0	1.120	3.094	.0366	2.095		
1.067									.139	10.6	.130	.819	.0095	.542		

Table 7.b

Summary of Data - Extended Skirt (10%) Parachute

C_D	t_f (sec)	r (ft)	S_o (ft^2)	l_s/D_o	R/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	[illegible]	Fr	Type of Test	Ref.
[illegible]			111.10	.600	1.354		.01	91	1.638	55.2	2.33[illegible]	3.411	.0399	2.310	Free Fall	28
1.[illegible]				1.080					.139	10.8	.135	.815	.0097	.552		
.[illegible]23									.139	11.4	.1[illegible]0	.860	.0102	.583		
1.038									.274	15.1	.263	1.139	.0135	.772		
.748									.274	17.8	.366	1.301	.0159	.910		
1.023									.274	15.2	.267	1.147	.0136	.777		
.818									.679	26.8	.830	2.022	.0240	1.369		
.788									.679	27.1	.861	2.060	.0244	1.395		
.876									.679	25.9	.775	1.954	.0232	1.323		
.719				.600					1.638	44.[illegible]	2.278	3.365	.0393	2.279		
1.048				.920					.132	10.7	.132	.807	.0096	.547		
1.048									.132	10.7	.132	.807	.0096	.547		
1.130									.123	10.3	.123	.777	.0093	.526		
.915									.299	16.1	.299	1.215	.0145	.823		
.870									.314	16.5	.314	1.245	.0148	.843		
.820									.333	17.0	.333	1.283	.0153	.869		
.810									.837	27.1	.837	2.045	.0244	1.385		
.302									.753	25.7	.753	1.939	.0231	1.313		
.817									.831	27.0	.831	2.037	.0243	1.380		
.908									1.998	41.5	1.998	3.132	.0367	2.121		
.832									2.185	43.4	2.185	3.275	.0384	2.218		
.850									2.089	41.9	2.089	3.162	.0368	2.141		
1.168									.119	10.2	.119	.770	.0092	.521		
.858									.161	11.9	.161	.898	.0171	.608		
1.022									.135	10.9	.135	.823	.0098	.557		
.905									.274	16.3	.303	1.230	.0147	.833		
.915									.274	16.2	.299	1.222	.0146	.827		
.950									.274	15.9	.288	1.120	.0143	.812		
.860									.679	26.7	.788	1.984	.0237	1.343		
.723									.679	28.7	.939	2.166	.0238	1.466		
.765									.679	27.9	.887	2.105	.0251	1.426		
.621				.600					1.638	48.0	2.638	3.660	.0423	2.452		
1.013				.760					.139	10.9	.137	.822	.0098	.557		
.895									.139	11.6	.155	.875	.0140	.608		
.810									.139	12.2	.171	.921	.0109	.623		
.777									.274	17.5	.352	1.321	.0157	.894		
.930									.274	16.0	.294	1.207	.0143	.818		
.751									.274	17.8	.364	1.343	.0160	.910		
.727									.679	28.5	.934	2.151	.0256	1.456		
.797									.679	27.2	.851	2.052	.0244	1.390		
.711									.679	28.8	.[illegible]64	2.173	.025[illegible]	1.472		
.744									1.820	45.3	2.442	3.418	.0398	2.315		
.718									1.830	46.2	2.252	3.486	.0406	2.361		
.831									1.810	43.5	2.540	3.282	.0382	2.223		
.810									.139	12.2	.171	.921	.0109	.623		
.979									.139	11.1	.142	.838	.0100	.567		
.945									.139	11.3	.147	.853	.0103	.577		
.844									.274	16.8	.324	1.268	.0151	.858		
.813									.274	17.1	.336	1.290	.0153	.874		
.844									.274	16.8	.324	1.268	.0151	.858		
.768									.679	27.8	.889	2.098	.0249	1.421		
.742									.679	28.3	.921	2.135	.0254	1.446		
.753									.679	28.1	.908	2.120	.0252	1.436		
.845				.600					.139	11.9	.142	.898	.0107	.608		
.903									.139	11.5	.153	.868	.0103	.588		
.858									.139	11.8	.162	.890	.0106	.602		
.770									.274	17.5	.355	1.323	.0157	.894		
.766									.274	17.7	.357	1.336	.0159	.904		
.725									.274	18.2	.378	1.373	.0163	.930		
.686									.679	29.2	.983	2.203	.0262	1.492		
.694									.679	29.4	.977	2.218	.0264	1.502		
.701									.673	29.2	.963	2.203	.0258	1.492		
.950			3546.74	1.000	.8333		.0025	108.[illegible]	.685	24.6	.832	10.130	.0221	.529		5
.980								107.[illegible]	.679	24.1	.651	9.851	.0217	.518		
.920								115.0	.676	24.9	.685	10.060	.0225	.536		
.780								115.8	.603	25.6	.735	10.460	.0231	.550		
.780								107.5	.586	25.2	.712	10.300	.0227	.542		
.750								117.0	.589	25.5	.729	10.420	.0230	.548		
.880								120.2	.501	21.9	.538	8.952	.0197	.471		
.950								108.8	.500	21.2	.504	8.666	.0191	.456		

Table 7.c

Summary of Data - Extended Skirt (10%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2"H_2O$ ($ft^3/ft^2 min.$)	W/S_o (psf)	V (ft/sec)	q (psf)	$Re \times 10^{-6}$	M	Fr	Type of Test	Ref.
1.100			3546.74	1.000	.8333		.0025	127.8	.500	19.8	.440	8.093	.0178	.426	Free Fall	5
.990			3546.74	1.000	.8333		.0025	113.4	.498	20.7	.480	8.461	.0186	.445		5
.610			2456.00	1.010	.5007	0	.004	108.0	.651	31.5	1.100	10.920	.0275	.743		19
1.163									.366	17.3	.312	5.995	.0152	.480		
.686									.651	29.7	.979	10.290	.0261	.700		
.778									.366	21.0	.496	7.277	.0183	.495		
.985									.489	22.6	.516	7.831	.0198	.533		
.594									.651	31.8	1.130	11.020	.0280	.750		
.807									.651	27.3	.832	9.460	.0240	.644		
.637			1231.63	.810	.8586	.10	.003		.283	19.1	.443	4.800	.0171	.535		16
.845									.277	16.6	.323	4.147	.0147	.465		
.713									.277	18.1	.384	4.522	.0160	.507		
.606									.277	19.2	.452	4.825	.0173	.538		
.620									.280	19.1	.447	4.800	.0172	.535		
.673									.276	18.3	.404	4.599	.0164	.513		
.690			3217.00	.740	.5312	.09	0	130.0	.733	31.2	1.083	12.070	.0270	.688		10
.480									.716	36.6	1.598	14.200	.0317	.807		
.857									.713	27.3	.841	10.690	.0238	.602		
.625									.306	21.2	.506	8.273	.0185	.468		
.540									.707	33.7	1.309	13.440	.0297	.743		
.786									.306	18.8	.394	7.299	.0163	.413		
.689			1133.54	1.000	.9476			100.0	.670	25.6	.780	6.174	.0223	.733		15
.961									.672	24.1	.691	[illegible].812	.0210	.690		
.891									.672	25.0	.743	6.029	.0218	.716		
.870									.670	25.3	.762	6.101	.0220	.724		
.940									.671	24.4	.708	5.889	.0212	.699		
.888									.672	25.1	.750	6.053	.0218	.719		
.691									.683	28.7	.979	6.921	.0250	.804		
.918									.681	24.[illegible]	.702	6.005	.0216	.713		
.754									.685	27.5	.909	6.632	.0242	.787		
.720									.686	28.2	.946	6.801	.0248	.807		
.743			934.35	.870	1.044				.749	29.1	1.007	6.471	.0253	.877		
.927									.749	26.0	.804	5.693	.0225	.784		
.751										29.1	1.007	6.471	.0252	.877		
.729										[illegible]	1.0[illegible]	6.459	.0258	.890		
.674										30.7	1.121	6.722	.0268	.926		
.834										27.8	.920	6.087	.0243	.838		
.700										30.1	1.078	6.590	.0266	.908		
.834										27.6	.907	6.043	.0244	.832		
1.081				.950						24.2	[illegible]	5.299	.0210	.730		
.656										31.2	[illegible]	6.831	.0272	.941		
.889										26.7	[illegible]	5.8[illegible]	.0232	.805		
.740										29.3	[illegible]	6.415	[illegible]	.683		
.834										27.6	.907	6.043	.0262	.832		
.674										30.7	1.121	6.722	.0274	.926		
.795										28.3	.953	6.196	.0252	.853		
.782									.30	28.5	.966	6.240	.0252	.859		
.854			715.60	.750	.9276		.003			20.0	.464	3.720	.0180	.650		29
1.020										18.3	.388	3.400	.0165	.595		
1.100										17.6	.360	3.300	.0158	.562		
1.220										16.7	.324	3.100	.0150	.542		
.640										23.0	.632	[illegible]	.0207	.747		
.624										23.4	[illegible]	[illegible]	.0211	.760		
1.000										18.5	.396	[illegible]	.0166	.600		
.6[illegible]4										22.2	.570	4.130	.0200	.720		
.945										19.0	.418	3.560	.0170	.617		
.641										20.6	[illegible]	[illegible]	[illegible]	.668		
.572										21.8	.525	4.075	[illegible]	.707		
.910										25.8	[illegible]	[illegible]	.0232	.837		
.702										1[illegible].7	[illegible]	[illegible]	[illegible]	[illegible]		
	3.80		3217.00	.740	.5312	.09	.003	130.0	[illegible]	19[illegible]	[illegible]	77.[illegible]	[illegible]	4.274		10
	1.20								[illegible]	226.1	[illegible]	87.1[illegible]	[illegible]	[illegible]		
	1.50								.712	22[illegible].8	[illegible]	[illegible]	.1367	4.333		
	5.90								.712	226.5	[illegible]	87.[illegible]	.1368	4.332		
	1.60	5360.0							[illegible]	226.1	[illegible]	88.020	[illegible]	4.383		
	4.00								[illegible]	228.[illegible]	[illegible]	87.910	[illegible]	5.065		
	[illegible]	4560.0							[illegible]	227.2	[illegible]	[illegible]	[illegible]	5.008		
	[illegible]								[illegible]	2[illegible].7	[illegible]	[illegible]	[illegible]	5.00[illegible]		
	[illegible]	[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.008		
										[illegible]	[illegible]	[illegible]	[illegible]	5.008		

Table 7.d

Summary of Data - Extended Skirt (10%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2$" H_2O (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
		6370.0	3217.00	.740	.5312	.09	.003	130.0	.733	227.0	57.35	87.840	.1962	5.003		10
	4.80	5320.0							.716	226.5	57.36	87.850	.1961	4.992		
	4.20								.714	232.1	57.32	86.610	.1990	5.116		
	5.10	6270.0							.714	225.3	57.28	88.190	.1964	4.996		
									.307	226.1	57.30	88.020	.1964	4.983		
	4.70								.707	222.9	57.29	88.880	.1966	4.913		
	5.00								.306	226.1	57.28	88.020	.1964	4.983		
	1.20								.306	228.5	57.33	87.520	.1965	5.036		
	1.35	980.0	356.60	.711	[illegible]	0	0	Not Given	[illegible]	184.5	31.70	34.460	.1668	5.506	Free Fall	7
	1.34	1420.0								186.4	32.30	34.810	.1685	5.563		
	1.34	1040.0								186.4	32.30	34.810	.1685	5.563		
	1.32	1430.0								190.1	36.10	35.510	.1719	5.673		
	1.52	1250.0								190.1	36.10	35.510	.1719	5.673		
		1650.0								246.4	55.80	46.020	.2211	7.353		
		2100.0								246.4	55.80	46.020	.2211	7.353		
		2240.0								246.4	55.80	46.020	.2211	7.353		
		1700.0								246.4	55.80	46.020	.2211	7.353		
		2160.0								246.4	55.80	46.020	.2211	7.353		
	1.49	1475.0								208.1	32.70	32.500	.1934	6.211		
		1175.0								208.1	32.70	32.500	.1934	6.211		
		1275.0								208.1	32.70	32.500	.1934	6.211		
		1375.0								212.3	33.80	33.160	.1973	6.336		
		900.0								235.3	41.80	36.750	.2195	7.022		
		2250.0								250.0	47.20	39.050	.2322	7.461		
		1560.0								250.0	47.20	39.050	.2322	7.461		
		1525.0								250.0	47.20	39.050	.2322	7.461		
		1490.0								250.0	47.20	19.050	.2322	7.461		
		1700.0								250.0	47.20	39.050	.2322	7.461		
		1600.0								234.5	34.10	31.190	.2237	6.999		
		1300.0								234.5	34.10	31.190	.2237	6.999		
		1575.0								281.4	57.60	43.950	.2577	8.400		
		2050.0								283.5	58.50	44.280	.2596	8.460		
	1.21	2225.0								285.6	59.40	44.610	.2615	8.524		
		2140.0								285.6	59.40	44.610	.2615	8.524		
	1.26	2340.0								334.6	82.90	52.260	.3092	9.906		
	1.10	2800.0								334.6	82.90	52.260	.3092	9.986		
		2900.0								334.6	82.90	52.260	.3092	9.986		
	1.21	2650.0								336.7	84.00	52.590	.3114	10.050		
		2480.0								374.4	[illegible]	58.460	.3493	11.170		
		3000.0								410.8	[illegible]	64.160	.3701	12.260		
	1.17	3450.0								410.8	[illegible]	64.160	.3701	12.260		
	1.20	3050.0								410.8	[illegible]	64.160	.3701	12.260		
	1.08	3575.0								410.8	[illegible]	64.160	.3701	12.260		
	1.06	3800.0								410.8	[illegible]	64.160	.3701	12.260		
	1.48	3200.0								414.2	131.10	64.700	.3762	12.360		
	1.26	2500.0								418.3	149.20	65.340	.3884	12.480		
	1.08	3175.0								450.6	151.40	70.380	.4145	13.450		
	1.61	4000.0								453.9	154.20	70.900	.4176	13.550		
	1.42	3775.0								458.1	151.40	71.550	.4214	13.670		
	1.36	3550.0								458.1	151.40	71.550	.4214	13.670		
	.92	4575.0								504.1	190.40	78.750	.4681	15.050		
	1.00	1690.0								[illegible]	31.00	30.580	.2155	6.861		
	.87	2000.0								[illegible]	31.00	30.580	.2155	6.861		
	.89	1550.0								[illegible]	31.00	30.580	.2155	6.861		
	1.02	1525.0								[illegible]	31.00	30.580	.2155	6.861		
	.89	1435.0								243.7	35.20	32.420	.2089	7.273		
	.68	1950.0								243.7	35.20	32.420	.2089	7.273		
	.66	2100.0								243.7	35.20	32.420	.2089	7.273		
	.97	1925.0								243.7	35.20	32.420	.2089	7.273		
	1.11	1396.0								243.7	35.20	32.420	.2089	7.273		
	1.10	1810.0								[illegible]	[illegible]	33.230	[illegible]	7.455		
	1.02	1900.0								[illegible]	[illegible]	33.470	[illegible]	7.509		
	.95	1860.0								308.8	57.80	41.080	.2916	9.216		
	.67	2290.0								308.8	57.80	41.080	.2916	9.216		
		1900.0								308.8	57.80	41.080	.2916	9.216		
	1.02	2140.0								308.8	57.80	41.080	.2916	9.216		
		2900.0								368.2	81.20	48.980	.3457	10.990		
		2650.0								371.2	[illegible]	49.380	.3485	11.080		
	1.28	2650.0								[illegible]	[illegible]	49.380	.3485	11.080		
		2350.0								[illegible]	[illegible]	49.380	.3485	11.080		

Table 7. e

Summary of Data - Extended Skirt (10%) Parachute

C_D	t_r (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_p/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2"H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
		3400.0	804.30	1.000	.6250	0	.004	135.0	.424	193.0	41.50	38.600	.1690	6.010		6
		2600.0							.424	224.0	57.90	44.100	.1980	6.990		
		2275.0							.548	195.0	43.70	38.400	.1740	6.090		
		7450.0							.541	224.0	57.00	44.100	.1990	6.990		
		3400.0							.673	224.0	55.10	44.100	.1950	6.990		
		4200.0							.673	262.0	78.90	51.800	.2100	8.180		
	3.40	5845.0	2463.01	.699	.5714				.676	262.8	76.24	93.400	.2270	6.192		9
		4675.0							.676	262.3	76.29	93.220	.2260	6.180		
	3.50	6515.0							.679	262.3	76.26	93.220	.2260	6.180		
	4.70	4130.0							.394	261.4	76.27	92.900	.2260	6.159		
	11.00	2155.0							.394	227.6	57.30	80.890	.1970	5.362		
	4.90	4150.0							.396	227.7	57.89	80.920	.1980	5.365		
	4.50	2760.0							.396	228.8	57.83	81.320	.1970	5.391		
	7.20								.391	226.6	57.75	80.530	.1970	5.339		
	5.00								.391	227.4	57.33	80.820	.1960	5.358		
	8.10								.391	226.7	57.29	80.570	.1960	5.341		
	3.90								.391	225.2	57.30	80.040	.1960	5.306		
	1.54	1300.0	956.60	.731	.8596	0	0	30.0	.226	186.4	33.00	34.810	.1670	5.563	Free Fall	7
	1.77	975.0								186.4	33.00	34.810	.1670	5.563		
	1.63	1460.0								186.4	33.00	34.810	.1670	5.563		
	1.65	1500.0								192.3	36.20	35.920	.1723	5.739		
	1.68	1175.0								192.3	36.20	35.920	.1723	5.739		
	1.68	1550.0								[illegible]	54.20	45.670	.2179	7.297		
	1.62	1785.0								[illegible]	54.20	45.670	.2179	7.297		
	1.52	1750.0								[illegible]	54.20	45.670	.2179	7.297		
	1.64	1720.0								[illegible]	54.20	45.670	.2179	7.297		
	1.80	1725.0								[illegible]	54.20	45.670	.2179	7.297		
	1.12	1950.0								[illegible]	80.40	55.830	.2655	8.921		
	1.10	2300.0								[illegible]	80.40	55.830	.2655	8.921		
	1.24	2310.0								[illegible]	80.40	55.830	.2655	8.921		
	1.17	2135.0								298.9	80.40	55.830	.2655	8.921		
	1.06	2250.0								300.7	81.40	56.160	.2671	8.974		
		2200.0								302.6	87.10	56.520	.2711	9.031		
	1.27	2540.0								308.3	90.40	57.580	.2763	9.201		
	1.42	2450.0								308.3	90.40	57.580	.2763	9.201		
	1.31	1840.0								308.3	90.40	57.580	.2763	9.201		
	1.49	2250.0								308.3	90.40	57.580	.2763	9.201		
		1350.0								365.5	113.40	68.260	.3237	10.910		
		3250.0								368.3	121.30	68.790	.3262	10.990		
		2800.0								368.3	121.30	68.790	.3262	10.990		
		1690.0								370.1	125.90	69.120	.3322	11.050		
		4100.0								388.9	145.50	72.640	.3545	11.600		
		3700.0								406.9	152.20	76.090	.3582	12.140		
		2900.0								406.9	152.20	76.000	.3582	12.140		
		4150.0								406.9	152.20	76.000	.3582	12.140		
		4450.0								406.9	152.20	76.000	.3582	12.140		
		3275.0								420.7	172.60	78.570	.3818	12.550		
		2900.0								452.6	194.80	84.530	.4056	13.550		
	1.28	4200.0								458.2	178.70	85.580	.4106	13.670		
	1.12	1650.0								208.1	24.60	32.500	.1865	6.211		
	1.09	1375.0								208.1	31.40	32.500	.1900	6.211		
	1.11	1350.0								208.1	31.40	32.500	.1900	6.211		
		1825.0								208.1	31.40	32.500	.1900	6.211		
	.99	1625.0								208.1	31.40	32.500	.1900	6.211		
	1.02	1500.0								208.1	31.40	32.600	.1900	6.211		
		1400.0								212.3	34.00	33.160	.1980	6.336		
		915.0								214.4	34.70	33.490	.2000	6.399		
		1200.0	715.60	.750	.9276		.003	100.0		150.0	24.90	280.000	.1340	4.870		29
		1500.0			.9276		.003	100.0		150.0	24.90	280.000	.1340	4.870		
		1000.0			.9276		.003	100.0		150.0	24.90	280.000	.1340	4.870		
		1250.0			.9276		.003	100.0		150.0	24.90	280.000	.1340	4.870		
12.5% Extension																
		4000.0	2605.00	.708	.9376	0	.004	104.5	.331	224.0	63.12	80.440	.2091	5.204	Free Fall	18
		5100.0							.484	226.0	67.76	81.160	.2098	5.250		
		5650.0							.638	221.0	64.52	79.360	.2081	5.134		
		6600.0							.331	299.0	114.50	107.400	.2821	6.946		
		6400.0							.484	299.0	111.00	107.400	.2800	6.946		
		7200.0							.638	293.0	109.60	105.200	.2762	6.807		
		5400.0							.331	336.0	146.50	119.200	.3188	7.805		

Table 7.f

Summary of Data - Extended Skirt (12.5%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_F/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2"H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
		4700.0	2605.00	.708	.9376	0	.004	104.5	.331	296.0	112.50	105.000	.2814	6.876		18
		4250.0							.331	227.0	65.44	80.170	.2131	5.273		
		3350.0							.331	229.0	65.16	81.020	.2128	5.320		
		5900.0							.638	232.0	66.31	81.800	.2148	5.389		
		8000.0							.638	311.0	124.60	109.800	.2874	7.225		
	6.8		804.2*	1.000	.625		0	120.0	.541	337.0	63.08	66.322	.2936	10.505	Free Fall	17
	3.0	2250.0							.686	225.0	57.21	44.280	.1963	7.014		
	3.3	2025.0							.561	224.0	57.52	44.138	.1965	6.983		
	1.9	2100.0							.554	198.0	44.26	39.015	.1731	6.172		
	3.5								.665	256.0	73.96	51.361	.2209	7.980		
	2.7								.663	258.0	73.62	50.034	.2245	8.042		
	3.6								.539	336.0	126.10	66.530	.2924	10.474		
	6.4	2785.0							.686	259.0	71.84	51.034	.2235	8.073		
	3.1								.540	224.0	56.35	44.356	.1953	6.982		
	3.3	2260.0							.686	224.0	56.65	44.356	.1958	6.982		
	1.3								.664	226.0	59.20	45.087	.1996	7.045		
	1.2								.664	223.0	56.44	44.268	.1949	6.951		
	1.2				.750		.002		.665	256.0	75.63	51.296	.2259	7.980		
	1.5						.002		.541	325.0	118.30	65.000	.2833	10.131		
	1.5						.001		.540	334.0	124.94	66.758	.2912	10.411		
	1.1						.002		.540	325.0	118.30	64.838	.2833	10.131		
	1.8						.002		.540	325.0	118.30	44.916	.2833	10.131		
	2.2						0		.665	256.0	73.40	51.361	.2232	7.980		
	2.9								.665	261.0	75.95	51.811	.2272	8.136		
	0.7								.665	259.0	79.16	50.972	.2210	8.074		
	1.1								.542	337.0	131.51	66.404	.2528	10.505		
	2.2	4810.0							.686	224.0	57.55	44.138	.2000	6.983		
	1.4	3475.0							.575	224.0	60.06	44.138	.2007	6.983		
		2825.0							.563	198.0	47.32	39.015	.1784	6.172		
	1.5								.665	248.0	145.44	49.476	.2230	7.731		
	1.6								.563	337.0	132.99	67.232	.2990	10.505		
		4050.0							.688	257.0	74.77	51.272	.2247	8.011		
		2980.0							.693	223.0	56.89	44.268	.1949	6.951		
		2800.0							.693	198.0	45.28	38.305	.1746	6.172		
	1.3								.664	259.0	78.89	51.034	.2270	8.074		
	4.5								.665	259.0	74.66	51.034	.2248	8.074		
	4.1								.665	259.0	73.79	51.097	.2237	8.074		
	8.2								.533	337.0	130.72	66.404	.3351	10.505		
	1.2								.672	253.0	75.94	51.034	.2270	8.074		
	3.8								.665	257.0	74.77	51.272	.2480	8.011		
	2.9								.665	257.0	74.77	51.272	.2480	8.011		
	2.0				.500				.665	256.0	74.70	51.361	.2257	7.980		
	1.5								.665	256.0	75.90	51.361	.2257	7.980		
	6.9								.664	262.0	76.60	52.009	.2280	8.167		
	4.7								.543	251.0	70.30	49.519	.2185	7.824		
	2.7								.543	338.0	127.40	66.601	.2942	10.526		
	1.6								.665	256.0	72.73	51.361	.2209	7.980		
	4.1	1910.0							.674	226.0	56.97	44.532	.1950	7.046		
	4.2				.625		.003		.665	258.0	79.41	51.216	.2310	8.041		
	5.1						.002		.665	258.0	79.41	51.216	.2310	8.041		
	2.0						0		.665	258.0	74.95	51.216	.2293	8.041		
							.008		.665	258.0	74.95	51.216	.2293	8.041		
	3.7						0		.665	256.0	75.92	51.361	.2259	7.979		
	2.1						0		.679	256.0	75.10	51.361	.2254	7.979		
	1.8						0		.679	321.0	118.96	63.250	.2833	10.005		
	3.1						.002		.641	256.0	75.27	51.370	.2257	7.979		
	1.8						.001		.665	256.0	75.27		.2257	7.979		
	1.9						.001		.665	256.0	75.27		.2257			
	1.9	3450.0					.002		.665	256.0	72.94		.2201			
	2.2	2550.0					.001		.679	256.0	72.94		.2201			
	1.9	2900.0					.001		.679	256.0	72.94		.2201			
	2.0	2200.0					.002		.679	256.0	72.94		.2224			
		3025.0					.001		.679	256.0	72.94	51.2[illegible]	.2224			
	1.4	[illegible]					.001		.679	256.0	72.94	51.361	.2224			
	1.7						.001		.541	337.0	12[illegible].6[illegible]	66.404	.2967	10.503		
	2.1						0		.665	257.0	73.97	51.272	.2241	8.011		
	4.8								.657	259.0	74.86	51.034	.2254	8.074		
	5.1								.657	259.0	75.13	51.034	.2258	8.074		
	2.0								.66[illegible]	259.0	77.14	51.097	.2254	8.074		
	2.8								.541	337.0	128.05	66.404	.2325	10.500		

Table 7. g

Summary of Data - Extended Skirt (12.5%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2$" H_2O (ft^3/ft^{2}min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-5}	M	Fr	Type of Test	Ref.
	1.20	3940.0							.685	224.0	56.37	44.138	.1961	6.983		
	1.80	2625.0							.566	224.0	56.30	44.138	.1961	6.983		
	1.40	3275.0							.566	228.0	59.37	45.886	.2000	7.107		
	1.50								.669	223.0	56.69	44.489	.1953	6.951		
	1.20								.670	216.0	54.07	43.092	.1864	6.733		
		4375.0	804.25		.7500				.679	256.0	75.50	51.361	.2257	7.980		17
	1.60	3676.0							.697	227.0	58.49	63.911	.2004	7.076		
	2.60	2375.0							.691	223.0	56.44	44.268	.1963	6.951		
	2.50	1775.0							.580	198.0	46.26	33.326	.1760	6.172		
	4.30								.546	337.0	62.63	66.404	.2933	10.505		
	3.20								.665	259.0	28.16	51.093	.2248	8.074		
	2.50								.667	256.0	69.40	42.900	.2200	8.000		
	5.50								.567	328.0	120.20	58.600	.2850	10.200		
		3100.0							.688	252.0	63.50	44.100	.2180	7.850		
	8.70								.667	252.0	70.10	44.[illegible]	.2180	7.850		
	2.80								.542	286.0	92.00	52.800	.2500	8.910		
	1.70								.668	252.0	72.00	46.900	.2210	7.850		
	1.20		600.00		.7520				.668	252.0	69.80	44.300	.2170	7.850		8
	1.30								.668	252.0	69.80	44.300	.2170	7.850		
	2.50								.542	345.0	137.40	63.800	.2990	10.750		
	1.90								.542	328.0	124.20	60.670	.2950	10.210		
	3.20	2450.0							.689	222.0	55.60	41.100	.1940	6.910		
	1.20								.667	252.0	73.00	47.500	.2210	7.850		
	8.10								.667	252.0	76.50	52.400	.2265	7.850		
	3.30	2400.0							.665	254.0	73.79	51.036	.2237	8.074		
	2.30						0	120.0	.665	224.0	55.09	44.138	.1933	6.983		
	1.70	3100.0		1.000		·			.541	337.0	126.86	66.322	.2925	10.505		
	1.70								.563	198.0	44.57	33.015	.1734	6.172		
	1.30								.672	223.0	57.64	44.489	.1970	6.951		
	1.40								.670	223.0	56.69	44.268	.1956	6.951		
		3310.0							.710	223.0	55.70	44.268	.1931	6.951		
		4100.0							.566	196.0	43.91	38.908	.1715	6.110		
	1.90								.540	335.0	128.16	66.501	.2933	10.443		
	6.10	2290.0				0			.693	255.0	72.05	51.246	.2206	7.949	Free Fall	
	2.60								.539	230.0	58.71	45.720	.2002	7.169		
	2.70								.666	259.0	75.97	51.014	.2270	8.074		
		2050.0							.665	257.0	76.29	51.017	.2272	8.011		
	1.50								.665	259.0	74.80	51.034	.2266	8.074		
	5.90	2325.0	804.25		.750				.679	224.0	55.67	44.138	.1988	6.983		17
	1.60	1920.0							.561	225.0	58.17	44.200	.1979	7.014		
	3.70								.541	345.0	138.59	67.900	.3010	10.754		
	3.80	2300.0							.685	224.0	56.30	44.138	.1955	6.983		
	2.90	1700.0							.560	198.0	44.97	39.063	.1737	6.172		
	3.00								.664	257.0	75.83	51.272	.2256	8.011		
		2410.0							.678	223.0	59.13	44.268	.1991	6.951		
	1.50								.665	226.0	58.41	44.559	.1998	7.045		
	2.50								.664	261.0	72.53	51.811	.2272	8.136		
	5.50								.554	336.0	126.19	66.636	.2319	10.474		
		3100.0							.684	259.0	74.35	51.034	.2240	8.074		
	2.80								.560	293.0	76.41	58.020	.2556	9.133		
	1.70								.665	259.0	78.58	51.036	.2270	8.074		
	1.20								.665	253.0	71.70	51.034	.2235	8.074		
	1.30								.665	253.0	71.70	51.066	.2235	8.074		
	2.50								.540	354.0	139.98	69.198	.3073	11.035		
		2880.0							.687	223.0	59.13	44.268	.1991	6.951		
.767									.133	12.3	.182	.973	.0113	.657		
.829									.139	12.6	.168	.936	.0109	.632		
.806									.133	12.6	.174	.951	.0111	.642		
.720									.185	14.3	.256	1.126	.0131	.753		
.740									.203	15.4	.276	1.162	.0140	.786		
.693									.229	17.9	.333	1.313	.0153	.886		
.612			111.11	1.000	1.00		.01	1.90	.390	30.3	.861	2.181	.0262	1.472		20
.685									.635	27.1	.327	2.136	.0255	1.402		
.693									.635	28.3	.877	2.135	.0248	1.442		
.590									1.792	51.0	3.030	3.866	.0464	2.598		
.720									1.730	46.3	2.619	3.576	.0421	2.459		
.704									1.813	45.3	2.391	3.518	.0407	2.300		
.736									.133	13.2	.191	.986	.0116	.672		
.830									.133	12.6	.168	.936	.0103	.632		
.830									.133	12.6	.168	.936	.0109	.632		

Table 7.h

Summary of Data - Extended Skirt (12.5%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
.818									.229	16.0	.280	1.207	.0140	.815		
.708									.229	17.2	.324	1.298	.0151	.876		
.677									.229	17.6	.339	1.328	.0154	.896		
.582			111.1	1.009	1.345			108.0	.589	29.6	1.012	2.234	.0269	1.508		28
.655									.589	27.9	.899	2.105	.0253	1.421		
.623									.635	30.5	1.112	2.301	.0268	1.554		
.588									1.828	51.9	3.111	3.916	.0468	2.644		
.811						0			.331	18.0	.408	6.464	.0168	.418		
.548									.484	26.2	.884	9.408	.0243	.608	Free Fall	
.662									.638	27.0	.963	9.696	.0254	.627		
.471							.004		.330	23.4	.702	8.403	.0221	.544		
.632			2605.0	.708	.9476			104.5	.484	24.6	.765	8.834	.0230	.572		18
.585									.331	21.1	.565	7.446	.0190	.490		
.665									.331	20.0	.497	8.841	.0186	.465		
.496									.638	32.3	1.285	11.400	.0299	.750		
.597									.638	28.8	1.068	10.160	.0266	.569		
.313			800.00	1.000	.7520		0	120.0	.689	44.2	2.200	8.180	.0306	1.375		
.368			800.00	1.000	.7520		0	120.0	.690	39.7	1.875	7.910	.0354	1.235		

14.3% Extension

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ at ΔP=1/2"H_2O (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
1.112									.139	10.7	.124	.807	.0094	.547		
1.093									.139	10.8	.127	.815	.0094	.552		
1.163									.139	10.4	.119	.785	.0092	.532		
.874									.274	17.0	.314	1.283	.0149	.869		
.874									.274	17.0	.314	1.283	.0149	.869		
.927									.274	16.5	.295	1.245	.0144	.844		
.827									.724	28.4	.875	2.143	.0248	1.452		
.783									.724	29.2	.925	2.203	.0255	1.493		
.757									.724	29.6	.955	2.234	.0259	1.513		
.905								105.0	1.818	41.1	2.010	3.101	.0374	2.101		28
.950			111.1	1.009			.01		1.818	40.1	1.913	3.026	.0365	2.050		
.913									1.818	40.9	1.991	3.086	.0372	2.091		
1.041									.139	11.0	.133	.830	.0097	.562		
1.061									.139	10.9	.131	.023	.0096	.557		
1.287									.139	9.9	.108	.747	.0087	.506		
.849									.274	17.2	.323	1.298	.0150	.879		
1.007									.274	15.7	.269	1.185	.0139	.803		
.912									.274	16.6	.300	1.253	.0146	.849		
.738									.724	30.0	.981	2.264	.0263	1.534		
.690									.724	31.0	1.047	2.339	.0272	1.585		
.822									.724	28.4	.742	2.143	.0249	1.452		
.781									1.827	45.0	2.339	3.396	.0406	2.301	Free Fall	
.720					.844			175.2	.588	26.3	.775	10.750	.0237	.566		
1.020								175.2	.590	22.0	.543	8.993	.0198	.473		
1.320				1.20				128.8	.584	19.2	.413	7.848	.0173	.413		
.990								128.8	.586	22.3	.558	9.115	.0201	.480		
.990								128.8	.584	22.5	.568	9.197	.0203	.484		
.950								128.8	.586	22.8	.583	9.320	.0205	.490		
.800								175.2	.587	24.9	.695	10.180	.0224	.536		
.870								128.8	.584	23.8	.635	9.728	.0214	.512		
.830				1.10				128.8	.584	24.4	.667	9.974	.0220	.525		5
.690								128.8	.583	26.7	.799	10.910	.0241	.574		
.970								128.8	.584	22.6	.573	9.238	.0204	.486		
.790								175.2	.590	25.2	.712	10.300	.0227	.542		
.930							.003	175.2	.584	23.0	.593	9.401	.0207	.495		
.990			3540.0					175.2	.586	21.3	.509	8.707	.0192	.458		
.910								128.8	.586	23.3	.609	9.524	.0210	.501		
1.110								175.2	.585	21.1	.499	8.625	.0190	.454		
.890				.90				175.2	.588	23.6	.624	9.647	.0213	.508		
.636										28.6	.924	11.790	.0250	.615		
.827										25.5	.710	10.200	.0219	.548		
.870										24.7	.675	9.993	.0213	.531		
.553										30.7	1.062	12.630	.0267	.660		
.733				1.000			.04	115.0	.587	27.3	.801	10.790	.0233	.587		35
.603										29.6	.974	12.030	.0256	.637		
.782										26.2	.751	10.540	.0225	.563		
.855										23.2	.686	9.937	.0201	.499		
.816										24.7	.720	10.510	.0220	.531		
.836										24.1	.655	9.917	.0210	.518		
.727										26.6	.807	11.030	.0233	.572		

Table 7.i

Summary of Data - Extended Skirt (14.3%) Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ at $\Delta P = 1/2'' H_2O$ (ft^3/ft^2 min.)	W/S_o (psf)	V (ft/sec)	q (psf)	$Re \times 10^{-6}$	M	Fr	Type of Test	Ref.
.706									.587	27.0	.832	11.200	.0237	.581		
.832									.591	24.6	.710	10.460	.0218	.529		
.763									.590	26.5	.774	10.710	.0228	.570		
.808									.530	25.3	.731	10.990	.0222	.544		
1.090									.530	22.0	.540	8.971	.0190	.473		
.682									.587	27.7	.861	11.320	.0241	.596		
.685									.587	27.7	.857	11.300	.0240	.596		35
.679			3540.00	1.000	.8341	.04	.003	115.0	.587	27.3	.865	11.500	.0240	.587		
.754									.587	25.7	.778	10.930	.0228	.553		
.756									.587	25.2	.777	10.750	.0228	.547		
.925									.590	22.9	.638	9.766	.0206	.492		
.975									.590	21.0	.605	9.529	.0202	.495		
.756									.530	26.0	.780	10.890	.0229	.559		
.987									.590	22.8	.598	9.540	.0200	.490		
.758			5319.73	.972	.7776				.575	25.5	.759	12.765	.0226	.496		
.969			5319.73	.972	.7776				.573	22.5	.591	11.264	.0199	.437	Free Fall	
.855			5319.73	.972	.7776				.575	23.5	.672	12.350	.0212	.457		34
.911									.282	17.5	.352	7.164	.0154	.376		
.911									.282	17.4	.365	6.872	.0157	.374		
.846						0		100.0	.546	25.2	.753	10.316	.0226	.442		
.774			4157.00	.920	.7697		0		.594	27.8	.906	11.233	.0247	.598		
.653									.835	35.3	1.513	14.451	.0319	.759		25
.661									.835	34.9	1.494	14.124	.0317	.750		
.544									1.027	42.9	2.231	17.561	.0325	.922		
.530									1.027	44.1	2.277	18.053	.0391	.948		
		9180.0		.990					.353	327.7	116.1	157.900	.280	6.436		
		9750.0		.990					.365	366.5	149.0	181.100	.3160	7.198		
		9600.0							.480	278.7	86.8	138.000	.2419	5.473		33
		9540.0	5230.00		.7843				.480	324.3	116.6	159.600	.2804	6.369		
		14,350		.990					.480	404.0	183.5	201.000	.3514	7.934		
		17,300							.480	446.6	225.8	223.400	.3896	8.771		

Table 8.a

Summary of Data - Ringslot Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_F/D_o (/ft)	l_r/D_o	S_v/S_o	λ Geometric (%)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
.670										465.0	234.00	20.720	.413	29.250		
	.60	8,29[illegible]								529.0	302.00	22.600	.471	33.200		
.660										450.0	219.00	20.000	.400	28.400		
.570										403.0	176.00	17.850	.358	25.420		
.660										358.0	138.00	15.950	.318	22.580		
.650										328.0	116.00	14.620	.292	20.700		
.680										298.0	96.00	13.280	.265	18.780		
.710										269.0	78.00	11.980	.239	16.950		
.780										240.0	63.00	10.680	.213	15.120		
	.50	10,166								584.0	364.00	25.550	.518	36.830		
.660										500.0	267.00	21.850	.443	31.550		
.630										483.0	249.00	21.150	.427	30.500		
.640										465.0	231.00	20.350	.411	29.330		
.710										415.0	184.00	18.180	.367	26.150		
.730										362.0	140.00	15.850	.320	22.850		
.710										330.0	116.00	14.450	.292	20.800		
.770										287.0	88.00	12.560	.254	18.100		
.700										267.0	76.00	11.690	.236	17.850		
.770										251.0	67.00	10,000	.222	15.830		
.530										514.0	286.00	23.050	.457	32.350		
.570										480.0	249.00	21.510	.427	30.220		
.640										478.0	247.00	21.430	.425	30.150		
.750										385.0	160.00	17.260	.342	24.250		
.790										341.0	126.00	15.270	.303	21.500		
.810										311.0	105.00	13.950	.276	19.600		
.890										273.0	81.00	12.240	.243	17.200		
.880										256.0	71.00	11.480	.228	16.130		
.610										508.0	280.00	22.080	.454	32.100		
.600										476.0	245.00	20.650	.425	30.000		
.600										421.0	192.00	18.250	.376	26.600		
.620										388.0	163.00	16.850	.346	24.440		
.610										352.0	134.00	15.200	.314	22.180		4
.600			48.00	1.535	1.535			14.50		329.0	111.00	13.890	.286	20.180		
.6400									48.20	300.0	98.00	13.020	.268	18.910	Sled Test	
.690										547.0	321.00	24.050	.485	34.410		
.700										518.0	289.00	23.850	.459	32.600		
.710										450.0	217.00	19.850	.399	28.330		
.750										396.0	168.00	17,450	.351	24.900		
.720										357.0	137.00	15,750	.316	22,480		
.720										321.0	110.00	14.160	.285	20,220		
.740										301.0	97.00	13.280	.262	18,950		
.730										277.0	82.00	12.210	.246	17.450		
.590										534.0	307.00	23.300	.472	33.680		
.610										521.0	283.00	22.800	.461	32.800		
.610										509.0	276.00	22.210	.450	32.100		
.650										448.0	214.00	19.550	.397	28.250		
.680										400.0	171.00	17.450	.354	25.250		
.680										360.0	138.00	15,700	.319	22.700		
.710										328.0	115.00	14.310	.290	20.650		
.680										300.0	95.00	13.090	.265	18.920		
.690										280.0	84.00	12.220	.247	17.650		
.670										497.0	265.00	21.950	.441	31.300		
.670										496.0	264.00	21.900	.440	31.250		
.660										494.0	263.00	21.800	.440	31.100		
.670										489.0	252.00	21.350	.431	30.450		
.650										479.0	248.00	21.150	.426	30.150		
.620										472.0	238.00	20.720	.417	29.500		
.640										458.0	226.00	20.250	.408	28.850		
.660										448.0	215.00	19.830	.398	28.250		
.670										434.0	202.00	19,180	.385	27.300		
.650										400.0	172.00	17.670	.355	25.200		
.660										362.0	140.00	16.000	.321	22.800		
.640										330.0	117.00	14.580	.293	20.770		
.660										312.0	104.00	13.790	.277	19.650		
.660										290.0	90.00	12.810	.258	18.260		
.660										270.0	78.00	11.920	.240	17.000		
.564									.708	33.3	1.310	7.230	.030	1.007		
.738			[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	.708	29.1	1.015	6.310	.026	.880	Free Fall	
.564									.708	33.3	1.32[illegible]	7.230	.030	1.007		1
.529									[illegible]	[illegible]	1.411	7.447	.031	1.037		

Table 8.b

Summary of Data - Ringslot Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ Geometric (%)	W/S_o (psf)	V (ft/sec)	q (psf)	$Re \times 10^{-5}$	M	Fr	Type of Test	Ref.
.582									.703	32.8	1.290	7.121	.0315	.992		
.502									.708	35.3	1.494	7.664	.0319	1.067		
.539									.709	34.1	1.396	7.404	.0328	1.031		
.640									.710	31.3	1.175	6.796	.0301	.946		
.472									.717	36.6	1.606	7.946	.0352	1.107		
.522									.717	34.9	1.460	7.577	.0335	1.055		
.602			920.80	1.000	.9146		.0050	1.82	.711	32.3	1.251	7.013	.0310	.977		1
.457									.709	37.0	1.641	8.033	.0355	1.119		
.445									.709	37.5	1.686	8.142	.0360	1.134		
.588									.708	32.6	1.274	7.078	.0313	.986		
.626									.708	31.6	1.197	6.861	.0306	.956		
.639									.705	31.2	1.167	6.774	.0300	.943		
.676									.717	30.6	1.122	6.644	.0294	.925		
.686									.191	15.9	.279	1.151	.0156	.709		
.669			103.44						.465	25.9	.700	1.825	.0212	1.250		
.676					1.355		.0080	17.00	.464	25.2	.687	1.811	.0210	1.240		
.654									.465	25.6	.711	1.840	.0223	1.260		
.542									1.214	44.0	2.240	3.290	.0399	2.255		
.902									.100	9.8	.111	.727	.0088	.503		
.822									.198	12.4	.179	.913	.0112	.637		
.809									.197	12.5	.182	.930	.0113	.817		
.812									.193	14.3	.238	1.062	.0129	.734		
.789									.193	14.5	.245	1.063	.0131	.745		
.780									.196	14.6	.250	1.075	.0132	.750		
.696									.471	25.1	.677	1.775	.0218	1.238		
.714									.471	23.8	.660	1.750	.0208	1.222		
.705									.469	22.7	.598	1.671	.0205	1.166		
.696									1.228	38.6	1.764	2.840	.0348	2.026		
.505			100.00		1.964		.0070	10.00	1.227	45.3	2.430	3.334	.0409	2.327		
.678									1.315	39.1	2.060	2.880	.0353	2.010		
.792									.197	12.6	.186	.928	.0140	.647		
.846									.126	12.2	.193	.893	.0110	.627		
.846									.126	12.2	.169	.833	.0110	.627		
.719									.195	15.2	.272	1.120	.0137	.781		
.797									.193	14.9	.262	1.090	.0130	.740	Free Fall	
.787									.196	14.5	.246	1.068	.0131	.745		
.665									.472	25.6	.703	1.812	.0222	1.263		
.781									.471	22.7	.603	1.671	.0205	1.166		
.671									.470	25.5	.701	1.805	.0221	1.258		
.623									1.227	41.3	1.970	3.020	.0373	2.121		
.769									.100	10.5	.130	.766	.0095	.540		
.830									.097	10.1	.117	.755	.0092	.519		
.814				1.020					.096	10.2	.117	.771	.0092	.526		28
.680									.190	15.4	.280	1.153	.0139	.791		
.766									.192	14.6	.250	1.073	.0132	.750		
.679									.191	15.5	.282	1.152	.0141	.797		
.641									.456	26.3	.726	1.863	.0238	1.279		
.662									.465	25.5	.703	1.841	.0222	1.500		
.758									.465	22.9	.619	1.713	.0207	1.178		
.645							.0060	11.5	1.210	39.8	1.878	2.900	.0360	2.022		
.587									1.210	41.7	2.060	3.230	.0378	2.150		
.707									1.210	38.0	1.710	2.858	.0344	1.951		
.803									.102	10.3	.126	.760	.0093	.530		
.818									.100	10.2	.122	.763	.0093	.526		
.834			101.44		1.355				.100	10.1	.120	.756	.0091	.519		
.810									.191	14.2	.236	1.062	.0128	.730		
.799									.193	14.3	.262	1.068	.0130	.736		
.745									.191	14.8	.256	1.103	.0134	.761		
.684									.465	24.1	.680	1.722	.0200	1.238		
.667									.466	25.2	.638	1.810	.0220	1.190		
.746									.466	22.9	.625	1.712	.0202	1.178		
.467									1.212	47.7	2.595	3.564	.0428	2.450		
.692									.195	13.9	.210	1.003	.0126	.606		
.758									.100	10.6	.131	.794	.0096	.542		
.772									.100	10.5	.129	.786	.0095	.537		
.707							.0060	17.00	.191	15.2	.270	1.133	.0138	.779		
.698									.190	15.3	.272	1.145	.0138	.784		
.698									.190	15.3	.272	1.145	.0138	.784		
.648									.371	22.2	.576	1.660	.0201	1.127		
.673									.465	24.3	.691	1.820	.0220	1.265		

Table 8. c

Summary of Data - Ringslot Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft²)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	S_v/S_o	λ Geometric (%)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
.657			109.44	1.020	1.355		.008	17.80	.964*	24.8	.718	1.855	.0223	1.260	Free Fall	28
.597									1.212	46.9	2.390	3.360	.0406	2.305		
.560									1.209	42.7	2.159	3.200	.0386	2.169		
[illegible]									1.212	42.4	2.130	3.165	.0384	2.169		
.761									.099	10.7	.134	.802	.0097	.547		
.755									.100	10.6	.132	.794	.0096	.542		
.811									.100	10.1	.120	.756	.0092	.517		
.686									.191	15.4	.278	1.151	.0140	.790		
.721									.191	15.0	.264	1.121	.0136	.768		
.855			107.92	1.000	1.024		0	10.00	.102	10.0	.119	.744	.0089	.515		27
.791									.211	15.0	.267	1.116	.0134	.773		
.710									.527	25.0	.742	1.860	.0224	1.289		
.632									1.201	40.0	1.901	2.976	.0358	2.062		
.811			109.38		1.017			11.5	.096	10.0	.119	.749	.0089	.513		
.760									.203	15.0	.267	1.123	.0134	.769		
.685									.509	25.0	.742	1.872	.0224	1.282		
.612									1.163	40.0	1.901	2.996	.0358	2.051		
.751								17.0	.083	10.0	.119	.749	.0089	.513		
.714									.191	15.0	.267	1.123	.0134	.769		
.649									.482	25.0	.742	1.872	.0224	1.282		
.566									1.076	40.0	1.901	2.996	.0358	2.051		

Table 9. a

Summary of Data - Ribbon Parachute

C_D	t_f (sec)	F_s (lbs)	S_o (ft^2)	l_s/D_o	N_r/D_o (/ft)	l_r/D_o	[illegible]	λ Geometric (%)	W/S (psf)	V (ft/sec)	q (psf)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.730										476.0	[illegible]	[illegible]	[illegible]	[illegible]		
.730										466.0	222.0	[illegible]	.4511	28.40		
.740										402.0	171.0	18.39	[illegible]	[illegible]		
.720			54.00		1.930	1.43		15.3	[illegible]	358.0	135.0	16.30	.3159	21.30	Sled Test	
.800										324.0	111.0	14.80	.2859	19.80		
.770										2?2.0	90.0	13.33	.2575	17.80		
.790										267.0	75.0	12.20	.2359	16.30		
.690										250.0	66.0	11.40	.2200	15.30		
.580									42.86	308.0	107.0	15.74	.2770	18.40		
.590									42.84	278.0	86.0	14.26	.2500	16.70		
.590				1.000					42.94	258.0	74.0	13.23	.2320	15.43		
.600									42.84	240.0	64.0	12.31	.2158	14.41		
.520										515.0	[illegible]	26.36	.4627	30.93		
.510										488.0	265.0	24.98	.4384	29.31		
.540						1.395				460.0	235.0	23.54	.4133	27.63		
.510										411.0	188.0	21.03	.3693	24.68		
.520									40.81	369.0	151.0	18.88	.3315	22.16		
.510										333.0	123.0	17.40	.2992	20.00		
.520										303.0	102.0	15.51	.2722	18.20		
.520			56.60		1.885			19.5		277.0	85.0	14.18	.2489	16.64	Sled Test	
.490										261.0	76.0	13.36	.2345	15.68		
.560										501.0	217.0	25.24	.4510	30.09		
.520										460.0	234.0	23.18	.4140	27.81		
.540										425.0	199.0	21.41	.3830	25.70		
.550				1.013		1.413				398.0	175.0	20.05	.3580	24.06		
.550										375.0	155.0	18.89	.3380	22.67		
.630									70.53	501.0	252.0	24.53	.4310	30.09		
.630										470.0	222.0	23.01	.4060	28.41		
.720										415.0	173.0	20.32	.3580	25.09		
.640							0			410.0	169.0	20.08	.3530	24.79		
.540						1.373				482.0	249.0	23.60	.4250	29.14		4
.540						1.373				445.0	210.0	21.79	.3920	26.90		
.500										435.0	167.0	35.40	.3940	21.50		
.470										361.0	116.0	29.20	.3250	17.80		
.480										312.0	87.0	25.30	.2800	15.40		
.500										274.0	68.0	22.20	.2460	13.50		
.470			129.2	1.000	1.247	0		18.5	20.00	251.0	58.0	20.35	.2250	12.36		
.450										237.0	52.0	19.20	.2130	11.70		
.470										226.0	47.0	18.35	.2030	11.10		
.470										218.0	44.0	17.70	.1950	10.73		
.480										210.0	41.0	17.00	.1880	10.34		
.590										493.0	270.0	25.70	.4490	30.20		
.610										464.0	246.0	24.20	.4230	28.40		
.630										438.0	220.0	22.80	.3990	26.80		
.620										387.0	172.0	20.20	.3530	23.70		
.620			54.0		1.930	1.430		9.7	42.40	330.0	124.0	17.20	.3010	23.20		
.540										304.0	106.0	15.85	.2780	18.60		
.650										288.0	95.0	15.00	.2620	17.60		
.630										247.0	70.0	12.89	.2250	15.10		
.590									—	233.0	62.0	12.15	.2130	14.20	Sled Test	
.510										472.0	227.0	2?.70	.4030	28.80		
.530										431.0	183.0	23.00	.3730	26.10		
.540			56.6		1.885	1.40		13.5	45.00	392.0	156.0	17.25	.3390	23.70		
.550										355.0	128.0	15.60	.3080	21.40		
.540										337.0	116.0	14.80	.2920	20.40		
.500										491.0	248.0	22.36	.4270	29.80		
.530										431.0	198.0	19.60	.3820	25.90		
.550			58.0		1.862	1.38	-	24.0	44.00	399.0	166.0	18.15	.3470	24.00		
.560										367.0	140.0	16.70	.3210	22.10		
.580										337.0	117.0	15.33	.2930	20.30		
.660										470.0	232.0	21.33	.4130	28.80		
.680										399.0	178.0	18.11	.3610	24.40		
.6?0			54.00		1.930	1.43		15.3	47.80	366.0	141.0	16.60	.3220	22.40		
.700										330.0	114.0	15.00	.2900	20.20		
.710										302.0	96.0	13.70	.2660	18.50		
.710										270.0	81.0	12.60	.2450	17.00		
.710										25?.0	6?.0	11.61	.225?	15.70		
	.38	8004.0	58.0		1.862	1.373		24.0	42.7	500.0	270.0	25.32	.4520	30.46	Free Fall	
.550			58.0		1.862	1.379		24.0	42.7	465.0	2?3.0	24.13	.4310	28.91	Free Fall	
.550			58.0		1.862	1.379		24.0	42.7	466.0	[illegible]	24.13	.4310	28.91	Free Fall	

Table 9. b

Summary of Data - Ribbon Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ Geometric (%)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
.469			109.29	1.018	1.356		.008	20.0	1.168	46.3	2.487	3.464	.0416	2.377		
.555									.080	11.2	.144	.834	.0100	.577		
.609									.080	10.7	.132	.797	.0096	.551		
.581									.156	15.3	.269	1.139	.0137	.788		
.574									.156	15.4	.273	1.146	.0138	.793		
.574									.156	15.4	.273	1.146	.0138	.793		
.531									.387	25.2	.730	1.876	.0226	1.297		
.506									.387	25.8	.765	1.920	.0231	1.328		
.487									.387	26.3	.795	1.958	.0236	1.354		
.498									.850	38.5	1.705	2.866	.0345	1.982		
.478									.850	39.3	1.776	2.926	.0352	2.023		
.506									.850	38.2	1.678	2.844	.0343	1.966		
.595			108.12	1.023	1.364		.010	25.0	.080	10.8	.134	.804	.0097	.556	Free Fall	28
.595									.080	10.8	.134	.804	.0097	.556		
.628									.080	10.5	.127	.782	.0094	.541		
.586									.156	15.2	.266	1.132	.0136	.783		
.564									.156	15.5	.276	1.154	.0139	.798		
.564									.156	15.5	.276	1.154	.0139	.798		
.492									.387	26.1	.783	1.943	.0234	1.344		
.500									.387	25.9	.771	1.928	.0232	1.333		
.463									.387	26.9	.832	2.003	.0241	1.385		
.437									.850	41.1	1.943	3.060	.0369	2.116		
.473									.850	39.5	1.794	2.941	.0354	2.033		
.441									.850	40.9	1.924	3.045	.0367	2.105		
.565									.080	11.1	.142	.826	.0100	.571		
.520			3.84	1.020	7.236			20.0	31,200	233.8	60,000	2.794	.2040	27.710		
.480				1.030				10.0	2,400	67.5	5,000	.800	.0580	8.040		
.460				1.030				30.0	11,500	151.0	25,000	1.790	.1320	17.980		
.490			3.77	1.030				30.0	29,400	233.8	60,000	2.771	.2040	27.830		
.490				1.030	7.296			30.0	29,400	233.8	60,000	2.771	.2040	27.830		
.490				1.030				30.0	29,400	233.8	60,000	2.771	.2040	27.830		
.450				1.030				30.0	27,000	233.8	60,000	2.771	.2040	27.830		
.600				1.020					3,000	67.5	5,000	.789	.0580	8.090		
.570				1.020					14,250	151.0	25,000	1.765	.1320	18.090		
.600				1.020		0			36,000	233.8	60,000	2.732	.2040	28.000	Infinite Mass	21
.680			3.66	1.020	7.412			10.0	40,800	233.8	60,000	2.732	.2040	28.000		
.440				1.000					2,200	67.5	5,000	.789	.0580	8.090		
.640				1.000					3,200	67.5	5,000	.789	.0580	8.090		
.560				1.000					14,000	151.0	25,000	1.765	.1320	18.090		
.600				1.000					36,000	233.8	60,000	2.732	.2040	28.000		
.470									2,350	67.5	5,000	.807	.0580	8.000		
.510									12,750	151.0	25,000	1.805	.1320	17.900		
.460			3.84	1.020	7.236			20.0	11,500	151.0	25,000	1.805	.1320	17.900		
.520									31,200	233.8	60,000	2.794	.2040	27.710		
.530									31,800	233.8	60,000	2.794	.2040	27.710		
.600									.078	10.6	.136	.799	.0097	.542		
.636			111.10	1.009	1.345			26.0	.070	10.3	.246	.777	.0094	.527	Free Fall	28
.622									.142	14.2	.229	1.072	.0127	.726		
.639									.142	14.0	.222	1.056	.0125	.716		
.630			3.66	1.000	7.412			10.0	147,294	233.8	60,000	2.732	.2040	28.000	Infinite Mass	26
.409									.265	23.6	.646	1.781	.0214	1.207		
.413									.265	23.4	.635	1.766	.0212	1.196		
.592									.277	20.3	.460	1.532	.0181	1.038		
.494									.637	33.7	1.289	2.543	.0301	1.723		
.432									.637	36.5	1.251	2.754	.0322	1.866		
.451									.637	35.7	1.400	2.694	.0315	1.825		
.664							.010		.078	10.2	.118	.770	.0091	.521		
.722									.078	9.9	.108	.747	.0087	.506		
.708			111.10	1.009	1.345			26.0	.078	10.0	.110	.755	.0088	.511		
.647									.142	14.1	.220	1.064	.0125	.721	Free Fall	26
.626									.142	14.3	.227	1.079	.0127	.731		
.672									.142	13.8	.211	1.041	.0122	.706		
.464									.277	23.2	.598	1.751	.0205	1.186		
.489									.277	22.6	.567	1.705	.0200	1.155		
.530									.277	21.9	.523	1.653	.0192	1.120		
.366									.637	39.6	1.741	2.988	.0350	2.024		
.454									.637	35.9	1.405	2.709	.0315	1.835		
.607			109.29	1.018	1.356		.008	20.0	.099	11.0	.145	.823	.0100	.565		
.604			109.29	1.018	1.356		.008	20.0	.099	11.2	.151	.838	.0102	.575		
.663			109.29	1.018	1.356		.008	20.0	.099	11.2	.151	.838	.0102	.575		

Table 9. c

Summary of Data - Ribbon Parachute

C_D	t_r (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_g/D_o (/ft)	l_r/D_o	S_v/S_o	λ Geometric (%)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
.592									.191	16.4	.321	1.227	.0150	.842		
.585									.191	16.5	.327	1.235	.0151	.847		
.607									.191	16.2	.315	1.212	.0148	.832		
.532									.466	27.0	.875	2.020	.0246	1.386		
.514									.466	27.5	.908	2.058	.0251	1.412		
.517									.466	27.4	.878	2.050	.0247	1.407		
.499									1.167	44.7	2.338	3.345	.0402	2.295		
.497									1.167	44.8	2.348	3.352	.0403	2.300		
.527									1.167	43.5	2.214	3.255	.0392	2.234		
.652			109.29	1.018	1.356		.008	20.0	.110	12.0	.168	.898	.0108	.616	Free Fall	28
.520									.110	12.3	.177	.920	.0111	.632		
.631									.110	12.2	.174	.913	.0110	.626		
.610									.201	16.8	.330	1.257	.0152	.863		
.517									.201	16.7	.326	1.249	.0151	.858		
.625									.201	16.6	.327	1.242	.0150	.852		
.522									.476	27.9	.912	2.088	.0257	1.433		
.530									.476	27.7	.898	2.073	.0250	1.422		
.471									.476	29.4	1.011	2.200	.0257	1.510		
.422									1.167	48.8	2.762	3.651	.0439	2.506		
.461									1.167	46.7	2.530	3.494	.0412	2.398		
.500									41.000	376.0	157.0	19.900	.3410	22.600		
.460									41.000	374.0	157.0	19.800	.3390	22.400		
.470									41.000	369.0	146.0	19.500	.3350	22.200		
.470			56.60		1.885	1.396		19.5	41.000	360.0	135.0	19.100	.3270	21.600		
.460									41.000	351.0	135.0	18.600	.3190	21.100		
.480									41.000	346.0	124.0	18.300	.3140	20.800		
.470									41.000	344.0	124.0	18.200	.3120	20.600		
.440									41.000	341.0	124.0	18.000	.3000	20.400		
.590									39.800	514.0	290.0	26.200	.4600	30.700		
.590									39.800	448.0	221.0	22.900	.4000	26.800		
.540									39.800	405.0	180.0	20.600	.3620	24.200		
.580				1.00			0		39.800	[illegible]	141.0	18.300	.3210	21.400	Sled Test	4
.530									39.800	337.0	125.0	17.200	.3020	20.100		
.600									39.800	305.0	102.0	15.500	.2730	18.200		
.550			58.00		1.930	1.380		24.0	39.800	275.0	83.0	14.000	.2460	16.400		
.520									40.000	484.0	262.0	25.600	.4380	28.400		
.500									40.000	427.0	201.0	22.600	.3870	25.500		
.510									40.000	396.0	175.0	20.900	.3580	23.700		
.570									40.000	[illegible]	140.0	18.700	.3200	21.200		
.550									40.000	[illegible]	125.0	17.700	.3030	20.000		
.600									40.000	295.0	97.0	15.600	.2670	17.600		
	.136	12,805	54.00		1.930	1.43		9.7	42.600	488.0	270.0	25.600	.4440	[illegible]		
	.122	11,158	54.00		1.930	1.43		9.7	42.600	451.0	230.0	23.500	.4100	27.400		
	.185	4,751	56.60		1.885	1.43		19.5	40.600	400.0	181.0	21.200	.3630	24.000		
.610			3.67	1.060	7.402		.001	10.0	3.050	67.5	5.0	.790	.0580	8.100		
.500			3.82	1.350	7.255		.001	20.0	2.500	67.5	5.0	.807	.0580	8.100		
.500			3.78	1.400	7.293		.001	30.0	2.500	67.5	5.0	.801	.0580	8.040		
.570			3.67	1.060	7.402	0	.001	10.0	14.240	151.0	25.0	1.849	.1320	18.100		
.520			3.82	1.350	7.255		.001	20.0	13.000	151.0	25.0	1.890	.1320	17.900		
.470			3.78	1.400	7.293		.001	30.0	11.730	151.0	25.0	1.878	.1320	18.000	Infinite Mass	22
.610			3.67	1.060	7.402		.001	10.0	36.600	233.8	60.0	2.860	.2040	28.000		
.520			3.82	1.350	7.255		.001	20.0	31.200	233.8	60.0	2.330	.2040	27.700		
.490			3.78	1.400	7.293		.001	30.0	29.400	233.8	60.0	2.910	.2040	27.800		
.650			23.30		2.203			18.6	6.500	101.0	10.0	3.730	.0931	6.830		
.630			22.80		2.227			18.6	6.500	101.0	10.0	3.730	.0931	6.830		
.440			16.10	1.030	2.650	1.32		29.4	5.900	118.0	11.4	4.150	.1080	8.000		
.460			20.30		2.360			29.4	4.700	101.0	10.2	3.770	[illegible]	[illegible]		
.490			21.30		2.304		-	29.4	4.700	100.0	9.6	3.660	[illegible]	[illegible]		23
.760									42.600	422.0	201.0	[illegible]	.3890	[illegible]	Free Fall	
.680									42.600	418.0	197.0	21.750	.3800	[illegible]		
.570									42.600	398.0	179.0	20.900	.3620	24.200		3
.520									42.600	378.0	161.0	19.650	.3440	23.000		3
.540									42.600	[illegible]	142.0	18.950	.3220	21.600		
.710						1.43			42.600	321.0	116.0	16.700	.2920	19.500		
.820			54.00	1.000	1.930			9.7	42.600	294.0	98.0	16.300	.2670	17.860		
.720									42.600	267.0	80.0	14.900	.2410	16.220	Sled Test	4
.470									42.600	248.0	69.0	[illegible]	[illegible]	15.080		
.470									42.600	[illegible]	61.0	[illegible]	.2130	14.200		
.610									42.600	[illegible]	57.0	11.760	.2060	13.730		
.710								15.3	43.000	506.0	255.0	27.810	.4410	30.600		

Table 9.d

Summary of Data - Ribbon Parachute

C_D	t_f (sec)	F_o (lbs)	S_o (ft^2)	l_s/D_o	N_R/D_o (/ft)	l_r/D_o	S_v/S_o	λ Geometric (%)	W/S_o (psf)	V (ft/sec)	q (psf)	Re x 10^{-6}	M	Fr	Type of Test	Ref.
.530										473.0	242.0	23.58	.421	28.27		
.540										459.0	228.0	22.88	.409	27.43		
.540										443.0	212.0	22.08	.394	26.48		
.540										425.0	195.0	21.18	.378	25.40		
.540									42.70	394.0	168.0	19.64	.351	23.55		
.540			58.00		1.862	1.379		24.0		374.0	151.0	18.64	.333	22.36		
.540										338.0	124.0	15.00	.301	20.20		
.530										317.0	108.0	15.80	.282	18.95		
.560										295.0	94.0	14.71	.263	17.63		
.540										279.0	84.0	13.91	.248	16.68		
.540										263.0	75.0	13.11	.234	15.72		
.620										455.0	225.0	22.79	.406	27.33		
.590										451.0	221.0	22.59	.402	27.09		
.600										440.0	210.0	22.04	.392	26.43		
.570										436.0	206.0	21.84	.389	26.19		
.550										434.0	205.0	21.74	.387	26.07		
.560				1.000						420.0	192.0	21.03	.375	25.23	Sled Test	4
.560										383.0	159.0	19.18	.342	23.00		
.550										348.0	132.0	17.43	.310	20.90		
.550								19.50		314.0	107.0	15.73	.280	18.86		
.540										291.0	92.0	14.58	.260	17.48		
.520			56.60		1.885		0		42.80	282.0	86.0	14.12	.252	16.94		
	.28	7938.0								466.0	236.0	23.34	.416	27.99		
	.22	8316.0								495.0	272.0	25.38	.445	29.73		
.560						1.395				486.0	262.0	24.92	.437	29.19		
.550										486.0	262.0	24.92	.437	29.19		
.550										486.0	262.0	24.92	.437	29.19		
.540										470.0	245.0	24.10	.423	28.23		
.530										460.0	235.0	23.59	.414	27.63		
.540										446.0	221.0	22.87	.401	26.79		
.540										437.0	212.0	22.41	.393	26.27		
.550										425.0	200.0	21.79	.382	25.53		
.560										380.0	160.0	19.49	.342	22.82		
.560										342.0	130.0	17.54	.308	20.54		
		122.00	3.84	1.020	7.236			20.0		233.8	60.0	2.794	.2040	27.71		
		12.00		1.030						67.5	5.0	.800	.0580	8.04		
		50.00		1.030						151.0	25.0	1.790	.1320	17.98		
		119.00	3.77	1.030				30.0		233.8	60.0	2.771	.2040	27.83		
		119.00		1.030						233.8	60.0	2.771	.2040	27.83		
		119.00		1.030						233.8	60.0	2.771	.2040	27.83		
		109.00		1.030						233.8	60.0	2.771	.2040	27.83		
	.400	17.00		1.020						67.5	5.0	.789	.0580	8.09		
	.130	75.00		1.020					∞	151.0	25.0	1.765	.1320	18.09		
		173.00	3.66	1.020		0		10.0		233.8	60.0	2.732	.2040	28.00		
	.080	195.00		1.020						233.8	60.0	2.732	.2040	28.00	Infinite Mass	21
		17.00		1.000						67.5	5.0	.789	.0580	8.09		
		18.00		1.000						67.5	5.0	.789	.0580	8.09		
		71.00		1.000						151.0	25.0	1.765	.1320	18.09		
		168.00		1.000						233.8	60.0	2.732	.2040	28.00		
		12.00								67.5	5.0	.807	.0580	8.00		
	.270	55.00								151.0	25.0	1.805	.1320	17.90		
		47.00	3.84					20.0		151.0	25.0	1.805	.1320	17.90		
	.180	120.00								233.8	60.0	2.794	.2040	27.71		
	.190	125.00								233.8	60.0	2.794	.2040	27.71		
		186.00	3.66	1.000	7.412			10.0		233.8	60.0	2.732	.2040	28.00		

Table 10

Summary of Data - Ribless Guide Surface Parachute

C_D	t_f (sec)	F_o (lbs)	S_p (ft²)	l_s/l_p	N_p/l_p (/ft)	l_r/l_p	S/S_p	λ at Δp=1/2"H_2O (ft³/ft² min.)	W/S_p (psf)	V (ft/sec)	q (psf)	Re [illegible]	[illegible]	Fr	Type of test	Test No.
[illegible]				1.000					.161	10.8	.11[illegible]	.4[illegible]	.0090	.629		
[illegible]				1.000				100.0	.310	15.0	.267	.765	.0140	.9[illegible]		27
.930				1.000					.828	25.0	.743	1.241	.022[illegible]	1.570		
.930				1.000					2.730	40.0	1.901	1.910	.036[illegible]	2.519		
1.081									.161	11.2	.198	.557	.0106	.743		
.934									.161	11.7	.162	.582	.0106	.737		
1.000									.161	11.8	.164	.586	.0107	.743		
1.086									.310	15.5	.283	.770	.0141	.976		
1.130									.310	15.2	.273	.755	.0138	.957		
.982									.310	16.3	.314	.810	.0148	1.026		
1.010									.620	22.8	.613	1.133	.0207	1.436		
.955									.828	27.1	.867	1.347	.0246	1.707		
.955					1.278				.828	27.1	.867	1.347	.0246	1.707		28
1.028			48.100						2.730	47.3	2.651	2.351	.0429	2.979	Free Fall	
1.070				1.53			.0002		2.730	46.3	2.540	2.301	.0420	2.916		
1.047									2.730	45.8	2.486	2.276	.0416	2.884		
1.010						0		134.0	.161	11.6	.159	.577	.0105	.730		
1.043									.161	11.4	.153	.567	.0103	.718		
.975									.161	11.8	.164	.587	.0107	.743		
1.058									.310	15.7	.291	.780	.0142	.989		
1.130									.310	15.2	.273	.755	.0138	.957		
.970									.310	16.4	.317	.815	.0149	1.032		
1.044									.828	25.9	.792	1.287	.0235	1.631		
1.029									.828	26.1	.804	1.297	.0237	1.643		
1.095									.828	25.3	.755	1.257	.0230	1.593		
.950									2.730	49.8	2.766	2.475	.0450	3.136		
1.150			.765	1.33	12.16			1260	14,420	111.7	12,550	.600	.1000	19.838		
.890			.902	1.33	11.20			160	11,180	111.7	12,550	.600	.1000	19,027		
1.194			.615	1.33	13.56		0	275.0	15,000	111.7	12,550	.600	.1000	20,916		12
1.024			.765	1.33	12.16			30.0	12,850	111.7	12,550	.600	.1000	19,838		
1.024			.913	1.33	11.13				12,850	111.7	12,550	.600	.1000	18,962	Infinite Mass	
1.020			1,570	1.50	7.073			119.3	5,100	67.5	5,000	.555	.0580	9,660		
.970			1.570	1.50	7.073			119.3	24,220	151.0	25,000	1.300	.1320	21,600		22
1.050			1.570	1.50	7.073		.0002	119.3	63,000	233.8	60,000	2,016	.2040	33,400		
.880			1,820		6.569			119.3	4,400	67.5	5,000	.555	.0580	9,600		
.810			1.820		6.569			119.3	20,220	151.0	25,000	1.242	.1320	21,480		21
.910			1.820		6.569			119.3	54,600	233.8	60,000	1.923	.2040	33,260		
.860										516.0	304,000	19,900	.4710	36,700		
.840										488.0	271,000	18,800	.4460	34,700		
.830										458.0	228,000	17,650	.4170	32,600		
.800										408.0	190,000	15,150	.3720	29,000		
.760										368.0	156,000	14,200	.3350	26,200		
.790										326.0	121,000	12,570	.2970	23,200		
.730				1.32						302.0	104,000	11,630	.2750	21,500		
.750										279.0	88,000	10,750	.2540	19,800		
.780			30.000		1.942	1.75			69,700	264.0	79,000	10,180	.2400	18,800		
.700										505.0	287,000	11,800	.4570	35,900		
.740										478.0	258,000	11,150	.4340	34,000		
.780										453.0	231,000	10,580	.4110	32,200		4
.690							.0001	58.6		411.0	190,000	9,600	.3730	29,300		
.700										365.0	150,000	8,525	.3310	26,000		
.640										342.0	132,000	7,985	.3100	24,300		
.480										312.0	110,000	7,290	.2830	22,200	Sled Test	
.540			11.40	1.72	2.625				350,000	490.0	252,000	11,810	.4320	44,300		
.550			11.40	1.72	2.625	13.2			350,000	475.0	237,000	11,450	.4180	42,900		
.560			11.40	1.72	2.625				350,000	459.0	222,000	11,080	.4040	41,400		
.590			11.40	1.72	2.625				350,000	438.0	202,000	10,550	.3850	39,600		
.760			11.40	1.72	2.625	10.5			350,000	498.0	259,000	12,000	.4370	45,000		
.740			11.40	1.72	2.625	10.5			350,000	481.0	242,000	11,600	.4220	43,500		
.720			11.40	1.72	2.625	10.5			350,000	466.0	221,000	11,230	.4090	42,100		
.730			30.00	1.32	1.942	1.75			131,500	500.0	276,000	19,500	.4430	35,600		
.780			30.00	1.32	1.942	1.95			131,500	465.0	238,000	18,100	.4170	33,000		
	.100	9,212		1.30				61.0	72,290	419.3	180,000	15,210	.3828	29,040		
		8,138		1.30				61.0	72,290	391.7	160,000	14,620	.3558	27,090		
	.070	11,563	33.200	1.30				58.6	72,290	480.1	270,000	19,050	.4329	33,220		32
	.070	14,318		1.30				58.6	72,290	513.9	300,000	20,550	.4616	35,500		
	.050	12,957		1.30				61.0	72,290	587.1	360,000	21,910	.5333	40,600		

Aeronautical Systems Division, Dir/Aero-Mechanics, Flight Accessories Lab, Wright-Patterson AFB, Ohio.
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Unclassified Report

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